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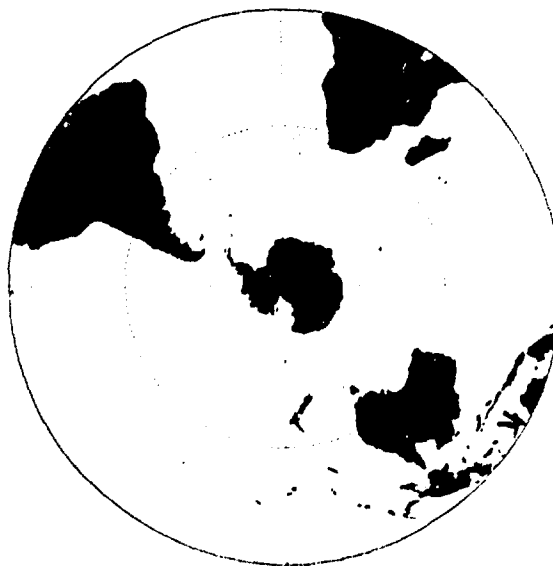
JOINT U.S. NAVY/U.S. AIR FORCE CLIMATIC STUDY OF THE UPPER ATMOSPHERE

VOLUME 4 - APRIL

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JULY, 1989

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PREPARED BY
NAVAL OCEANOGRAPHY COMMAND DETACHMENT
ASHEVILLE, N.C.

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OCT 04 1990
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PREPARED UNDER THE AUTHORITY OF
COMMANDER, NAVAL OCEANOGRAPHY COMMAND
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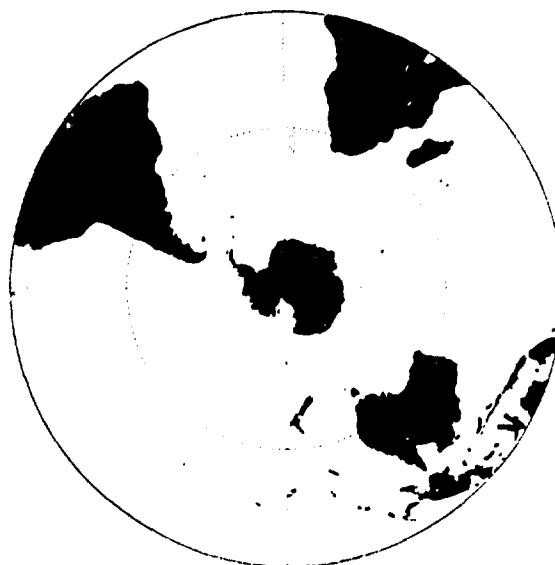
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19 ABSTRACT (Continue on reverse if necessary and identify by block number) This study of the upper atmosphere is based on 1980-85 twice daily gridded analysis produced by the European Centre for Medium Range Weather Forecasts. Included are global analyses of (1) Mean Temperature/Standard Deviation, (2) Mean Geopotential Height/Standard Deviation, (3) Mean Density/Standard Deviation, (4) Height and Vector Standard Deviation. All for 13 pressure levels - 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30 mb. In addition, analyses of (5) Mean Dew Point/Standard Deviation - levels 1000 through 300 mb, (6) jet stream (mean scalar speed) - levels 500 through 30 mb. Also included are global 5 degree grid point wind roses for the 13 pressure levels.				
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
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INTRODUCTION

During the past decade, improvements in the collection and assimilation of data required for more accurate representations of the atmosphere have resulted in data sets useful for developing a more definitive climatology of the global atmosphere. Such a climatology has uses in aircraft operations and planning, indirect assessments of atmospheric transport as well as a standard state from which atmospheric anomalies can be analyzed.

Prior climatologies, U.S. Navy (1959), U.S. Navy (1966), Naval Weather Service Command (1969), and Naval Weather Service Command (1970), were produced from individual station data with varying periods of record, and the resulting summarized data were analyzed. A serious deficiency was the lack of reporting locations in the major ocean basins. Analyses over the oceans were derived by extrapolating from known analyses over coastal regions as well as the few island or ocean vessels available. An additional complication was the manually intensive effort required to ensure horizontal and vertical consistency of the data.

With the advent, in the 1970s, of more powerful computers and data collection and assimilation systems, the initial analyses used for input into forecast models had a three-fold advantage over the station analyses utilized in the prior climatologies. First, the data assimilation system utilized a greater variety of information for production of an analysis. The normal array of land-based upper air reporting stations was supplemented by ship-based reporting stations, cloud reports, pilot reports and, most importantly, satellite-derived temperature, moisture and wind data. Consequent analyses more accurately represented the state of the atmosphere at a given observation time. Second, the assimilation system quality-controlled all incoming data and ensured the horizontal and vertical consistency of the resulting analyses. Finally, through the computer-based system, global data were available and archived in grid-point form.

A number of analysis sets produced by various national and international meteorological services were investigated. It is recognized that improvements to the data assimilation and analysis systems occurred within any analysis set produced, and that current analyses more accurately reflect the atmosphere's state than do the earlier analyses. It is also recognized that specific parameter or geographic-based deficiencies exist in all analysis sets. However, the intent of this upper-air climatology effort is the production of analyses to serve the needs of the operational meteorologist. A climatology derived from global analyses achieves this goal. Based on known capabilities and technical reviews of the various systems, as well as recommendations from the professional numerical modeling community, the analyses produced by the European Centre for Medium-range Forecasts were selected for processing.

ECMWF DATA

The European Centre for Medium-range Weather Forecasts (ECMWF) is an international organization established in 1973 and supported by 17 member states. It is responsible for providing global forecasts to the European community. Their data assimilation system consists of multivariate optimal interpolation analysis allowing the incorporation of a variety of observations with differing error characteristics and spatial distributions. A relatively comprehensive coverage of global data is ensured through the data collection schedule. A unique feature of the ECMWF system is the method of grid point analysis. Rather than analyzing individual grid points, varying sized boxes (depending on data density) are created containing groups of grid points. Grid point analysis uses data from within the box as well as adjacent boxes, thereby assuring a consistent analysis between all the grid points.

The system also includes internal quality control which examines the climatological reasonability of incoming data as well as the internal consistency of the data.

In addition, the system utilizes a model initialization process which ensures that harmful gravity waves, caused by imbalances in the analysis, with the potential to create problems in subsequent forecast fields, are suppressed. Through the initialization process, the atmosphere's mass and wind fields are adjusted so that only a portion of the gravity wave balanced by dynamic and physical processes is retained. Further information on the ECMWF system is available in Lorenc (1981), Shaw, et al. (1984), Lonnberg, et al. (1986), and ECMWF (1988).

The resulting initialized analyses are vertically interpolated to those 13 standard pressure levels: 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, and 30 mb, and include the geopotential height, temperature, and wind for all levels with moisture included for the 1000 through 300 mb levels.

Six years (1980-1985) of individual analysis were obtained from ECMWF on a 2.5° global grid. Although the analyses were permanently archived as spherical harmonic coefficients, ECMWF reconstituted the analyses for use in the data processing. Synoptic analyses at six-hour intervals were received for the six-year period, but only the 00 and 12Z analyses were re-sorted into a grid point sort. Given the quality control performed by ECMWF on collected data and the requirements for horizontal and vertical data consistency imposed by the assimilation system, minimal quality control was performed prior to summarization. Primary quality control was limited to comparison of level data against known/estimated climatological extremes.

The summarized grid point data were objectively analyzed, machine-contoured by parameter and level on polar stereographic (0°-90°N and S) and cylindrical equidistant (0°-60°N and S) projections with resulting contours machine-labeled. In addition, individual wind observations were consolidated into eight 45° segments centered on directions north, northeast, through northwest for display as wind roses on a series of cylindrical equidistant projections.

Since the ECMWF analyses were archived as spectral harmonic coefficients, the grid point reconstitution process provides data for all global 2.5° grid points. This naturally includes (for the 1000 through 700 mb levels) selected grid points at which the land elevations exceed the height of the pressure surface. For these grid points, a blanking program was used to eliminate both contours and grid point wind roses.

ANALYSES

1. Pressure-Height

Grid point geopotential height values (in dekameters) are summarized by month for 13 levels from 1000 mb to 30 mb with solid and dashed contours of mean values presented on pressure height charts. Standard deviation of height is calculated from the individual daily values with contours presented on a separate chart series including the standard deviation of vector mean wind. Local points of highest and lowest pressure are designated with H's and L's on the analyzed charts. Not all pressure centers are enclosed by closed contours. Vector mean wind in 5-knot increments are calculated for selected grid points considered adequate to depict flow for the hemisphere with wind shaft orientation related to specific latitude/longitude lines. Vector mean winds less than 2.5 knots are depicted as a shaft with no barbs. Contours of mean geopotential height and vector mean wind barbs are presented for the northern/southern hemispheres on polar stereographic projection and for 0° to 60° north and south on cylindrical equidistant projections with blanking for appropriate high elevation land areas on the 1000 through 700 mb charts.

2. Wind Roses

Wind roses for 10° grid points from 5° to 85° north and south are presented by month for all levels from 1000 mb to 30 mb. Each hemisphere is divided into three longitudinal zones: 60°W to 60°E, 60°E to 180°E, and 180°W to 60°W. Each rose presents:

- a) Scalar mean speed
- b) Percent frequency of occurrence from each of 8 cardinal point wind directions proportional to shaft length with dots on the shafts representing 5 percentile intervals.
- c) Mean speed for each of the 8 cardinal wind directions rounded to the nearest 5 knots.

Roses for grid points on the 1000 mb through 700 mb level charts are blanked whenever the land elevation exceeds the mean geopotential height of the specified level.

3. Temperature

Grid point temperature data (in °C) are summarized by month for 13 levels from 1000 mb to 30 mb with solid and dashed contours of mean values presented on pressure height charts. Temperature standard deviation derived from the individual observations are shown on the same charts with dotted contours. Contours are presented for both the northern and southern hemispheres on a polar stereographic projection and for the zone from 0° to 60° north and south on cylindrical equidistant projections with blanking for appropriate high elevation land areas on the 1000 through 700 mb charts.

4. Dew Point

Grid point moisture data were received as mixing ratios for the period through April 19, 1982 and as relative humidity thereafter for the 1000 through 300 mb levels. All moisture data were converted to dew point values. These are summarized by month with solid and dashed contours of mean values presented on pressure height charts. Dew point standard deviation derived from the individual observations are shown on the same charts with dotted contours. Contours are presented for both the northern and southern hemispheres on a polar stereographic projection and for the zone from 0° to 60° north and south on cylindrical equidistant projections with blanking for appropriate high elevation land areas on the 1000 through 700 mb charts.

5. Density

Grid point density data were computed from the daily values of temperature and pressure from the equation of state in the form

$$\rho = \frac{P}{RT}$$

where ρ is the density, P is the pressure, T is the temperature, and R is the gas constant. Density was computed for moist air through 300 mb and for dry air from 250 mb to 30 mb. Density data (in Kg/m³) are summarized by month for all 13 levels with solid and dashed contours of mean values presented on pressure height charts. Density standard deviation derived from individual observations are shown on the same charts with dotted contours. Contours are presented for both the northern and southern hemispheres on a polar stereographic projection and for the zone from 0° to 60° north and south on cylindrical equidistant projections with blanking for appropriate high elevation land areas on the 1000 through 700 mb charts.

6. Standard Deviation of Height and Vector Mean Wind

Standard deviation of the height and vector mean wind data presented on the pressure height charts are presented on monthly charts for the 1000 through 30 mb levels. Height standard deviations (in dekameters) are presented as solid contours and vector wind standard deviations (in knots) as dashed contours. Contours are presented for both the northern and southern hemispheres on a polar stereographic projection and for the zone from 0° to 60° north and south on cylindrical equidistant projections with blanking for appropriate high elevation land areas on the 1000 through 700 mb charts.

7. Jet Stream

Grid point scalar mean wind speed (in knots), as presented by the value in the center of the wind rose octagons, are summarized by month and analyzed for 500 through 30 mb. All speeds exceeding 50 knots are shaded with shading intensity increasing by 25-knot increments. Contours are presented for both the northern and southern hemispheres on a polar stereographic projection and for the zone from 0° to 60° north and south on cylindrical equidistant projections.

DATA AVAILABILITY

Monthly summarized grid point data for the period of record for all levels from 1000 through 30 mb have been retained on magnetic tape. Data available, per level, include:

- Number of observations
- Mean zonal wind component and standard deviation
- Mean meridional wind component and standard deviation
- Vector mean wind and standard deviation
- Mean temperature and standard deviation
- Mean dew point (through 300 mb) and standard deviation
- Mean geopotential height and standard deviation
- Mean density and standard deviation
- Mean scalar wind speed and percentage of observations for each designated direction

Similarly summarized data for each half-month of the 1980-85 period are also available on magnetic tape. Summaries can be provided on magnetic media or in listing form by the National Climatic Data Center.

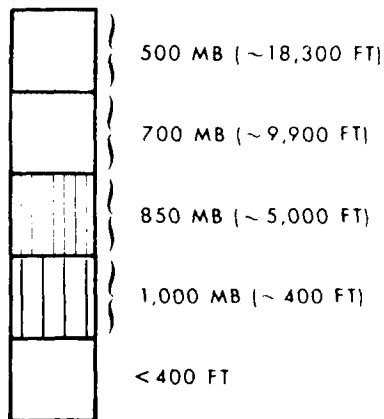
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- U.S. Navy, 1966: Components of the 1000 mb Winds of the Northern Hemisphere, NAVAIR 50-1C-51.

PRESSURE - HEIGHT
(13 LEVELS, 1000 TO 30 MB)

- Contours of mean height (solid and dashed lines) in geopotential dekameters:
example: 580 is 5800 geopotential meters; solids labeled, dashed intermediates unlabeled
- Height labeled interval:
 - 6 dekameters (60 meters) - 1000 MB to 400 MB
 - 12 dekameters (120 meters) - 300 MB to 200 MB
 - 8 dekameters (80 meters) - 150 MB to 30 MB
- Vector mean wind in knots
- Contours blanked for geographic areas with elevations exceeding specified geopotential heights

ELEVATION SCALE



Mean Geopotential Height (dkm)

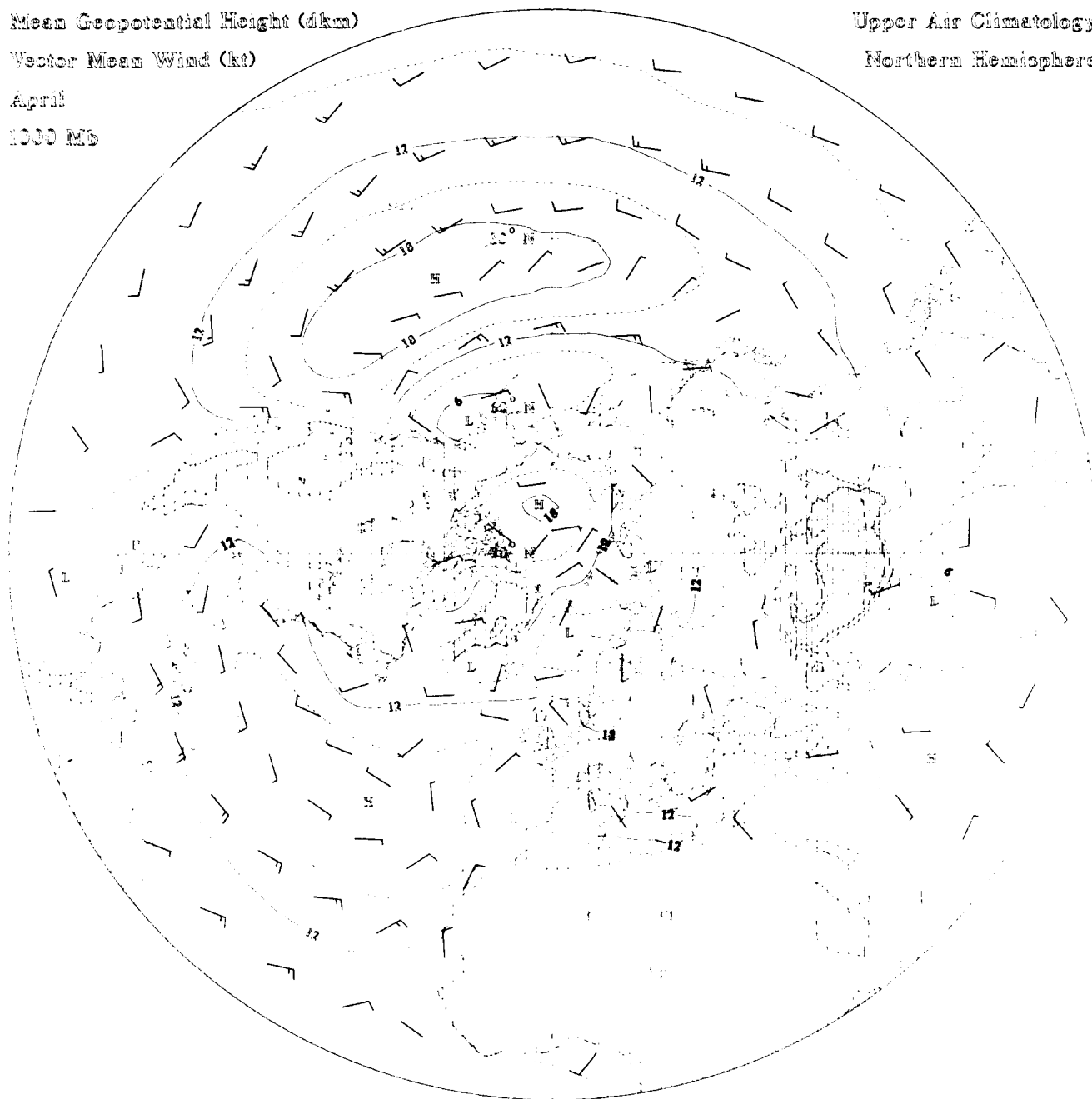
Vector Mean Wind (kt)

April

1000 Mb

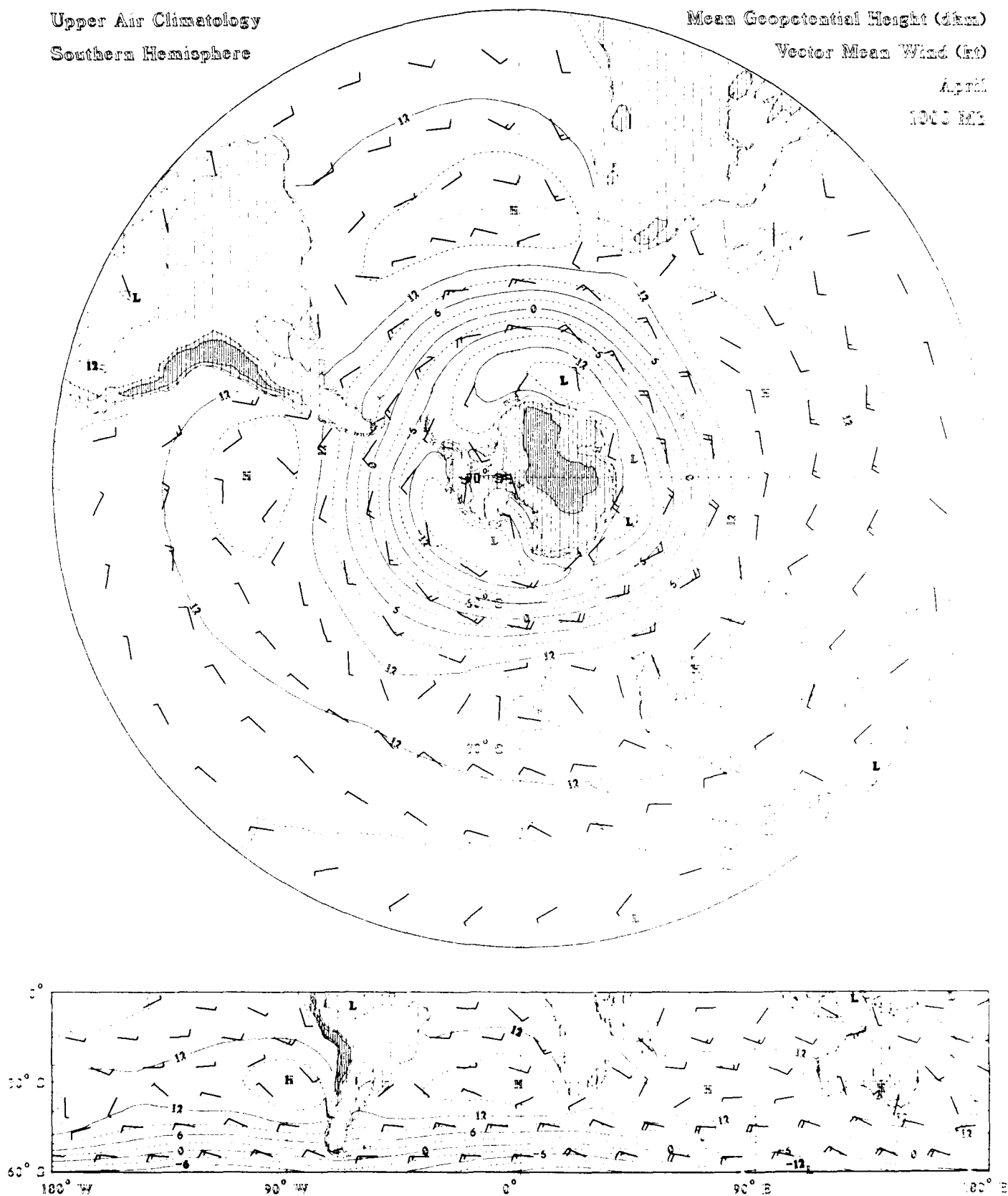
Upper Air Climatology

Northern Hemisphere



Upper Air Climatology
Southern Hemisphere

Mean Geopotential Height (dkm)
Vector Mean Wind (m/s)
April
1000 mb



Mean Geopotential Height (dkm)

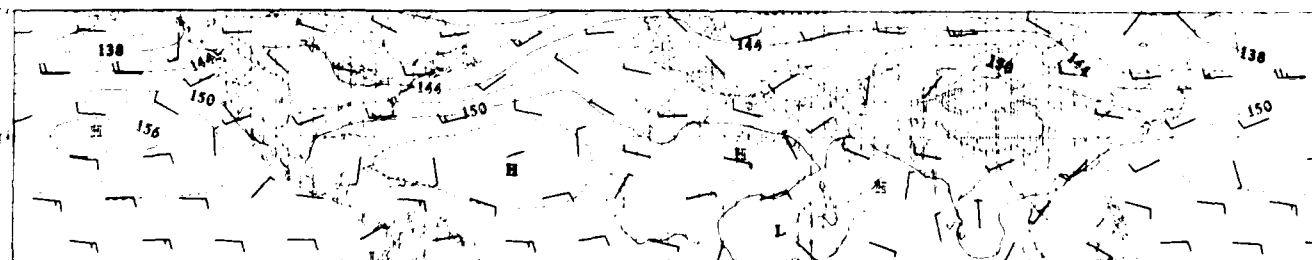
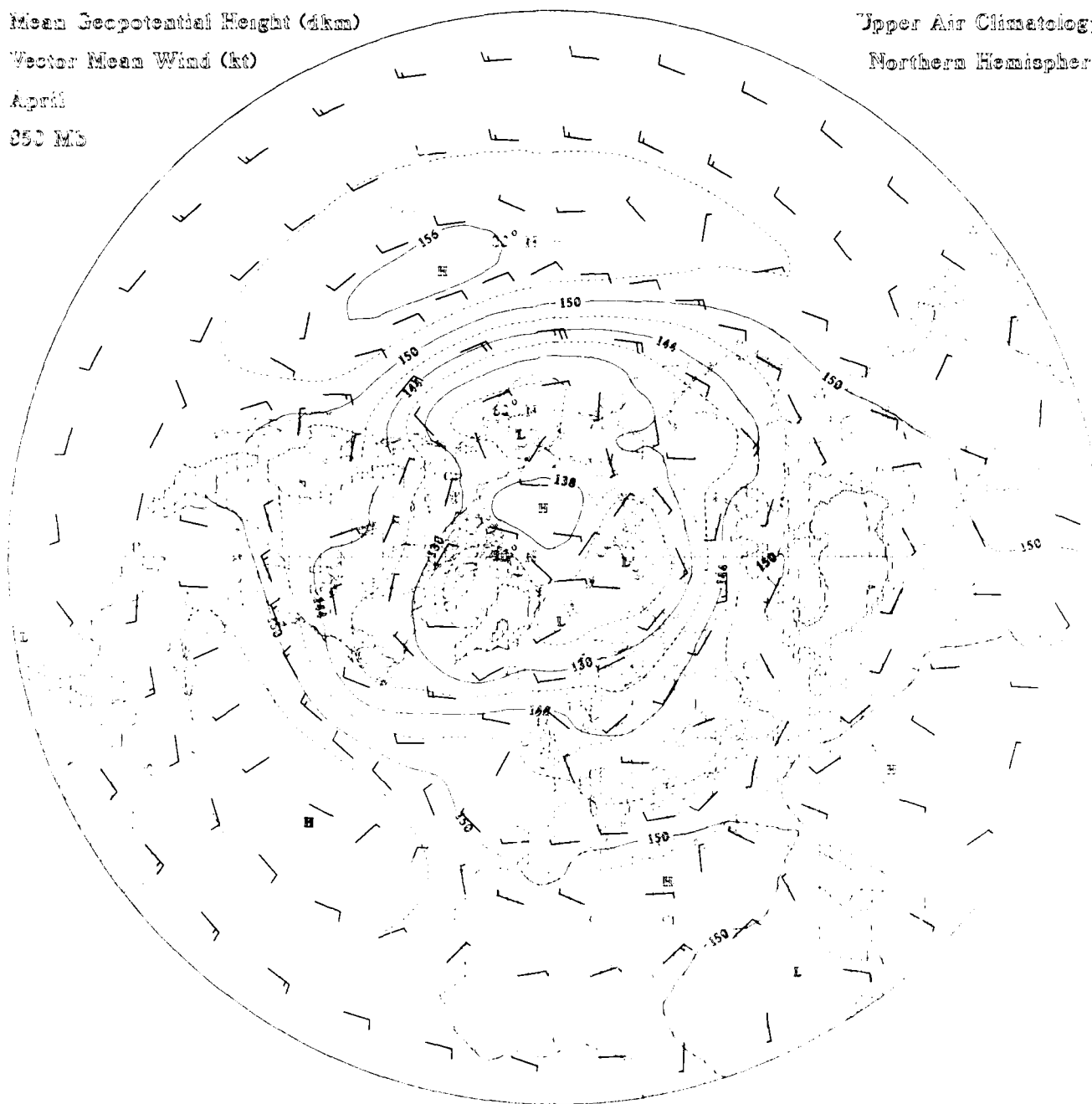
Vector Mean Wind (kt)

April

850 MB

Upper Air Climatology

Northern Hemisphere



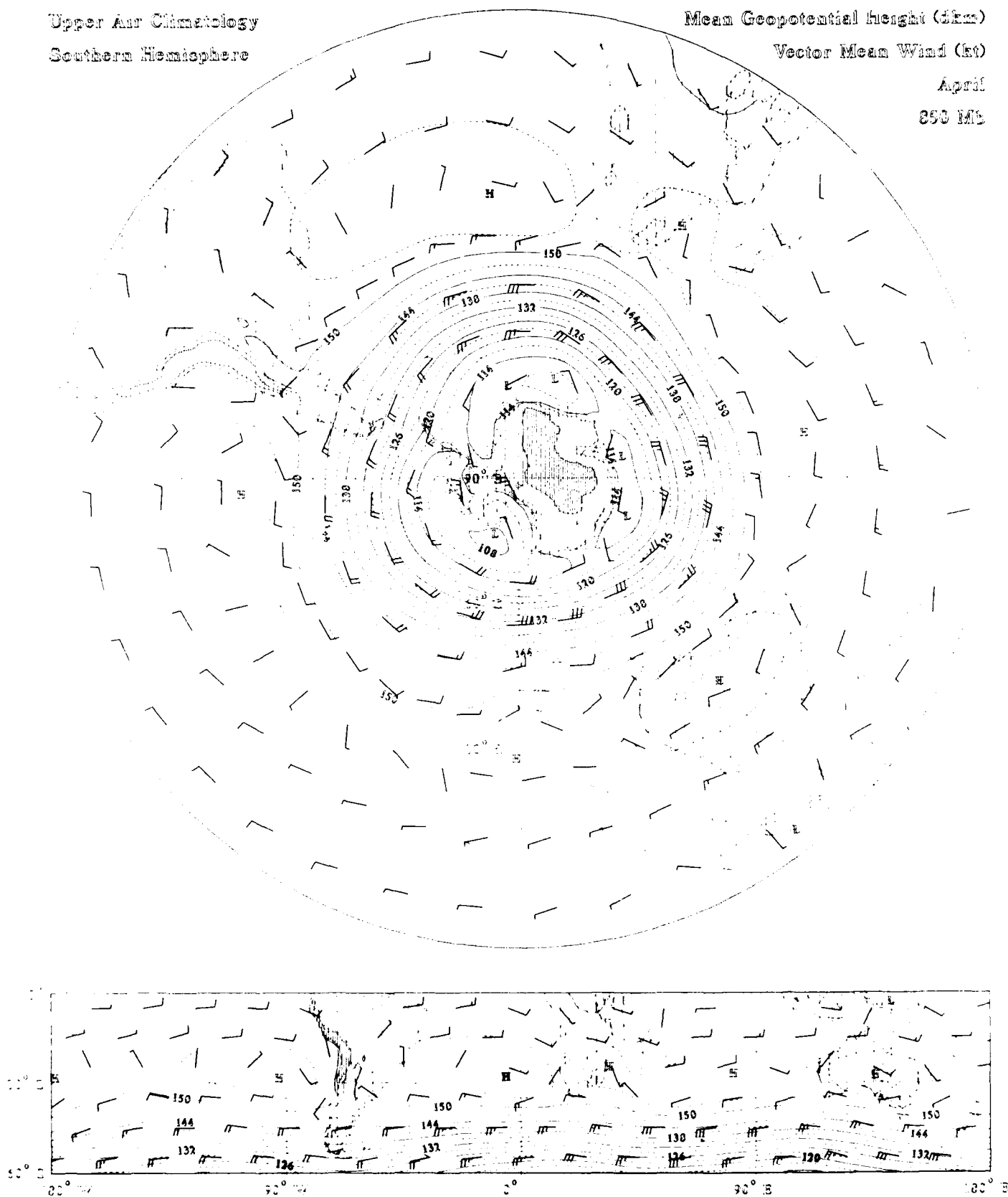
Upper Air Climatology
Southern Hemisphere

Mean Geopotential Height (gkm)

Vector Mean Wind (kt)

April

850 MB



Mean Geopotential Height (dkm)

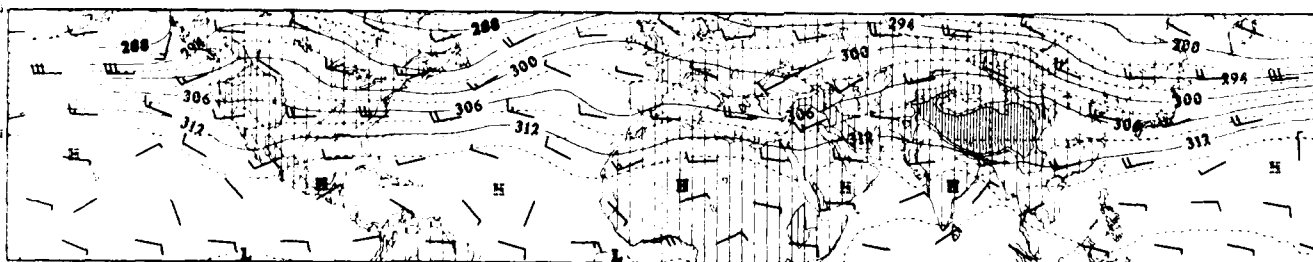
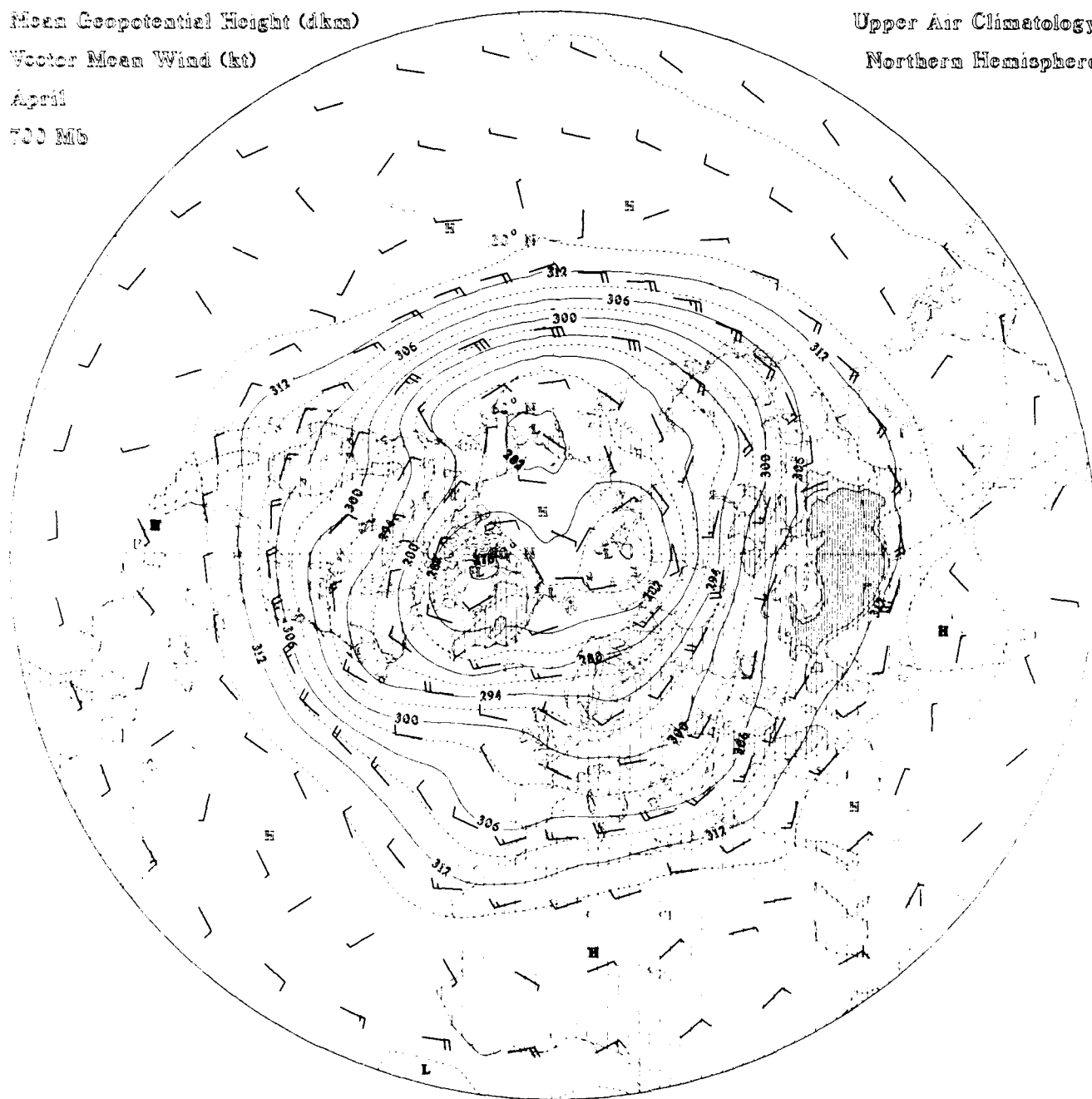
Vector Mean Wind (kt)

April

700 Mb

Upper Air Climatology

Northern Hemisphere



20° W 90° W 0° 90° E 180° E

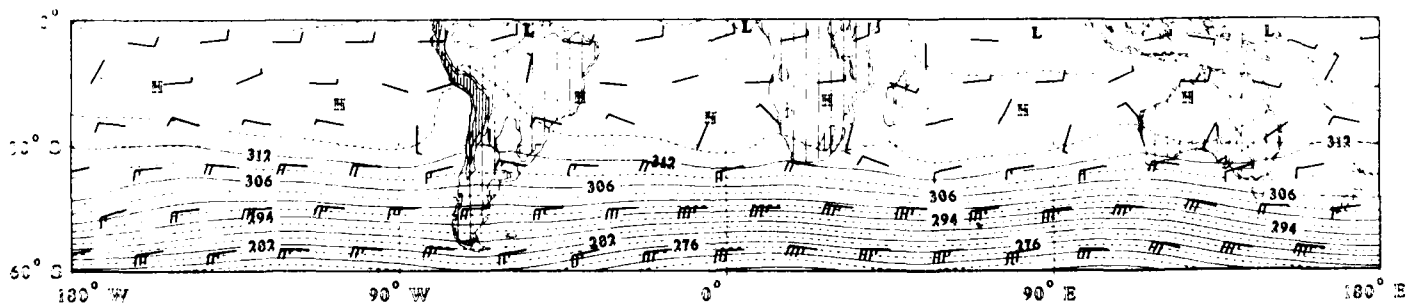
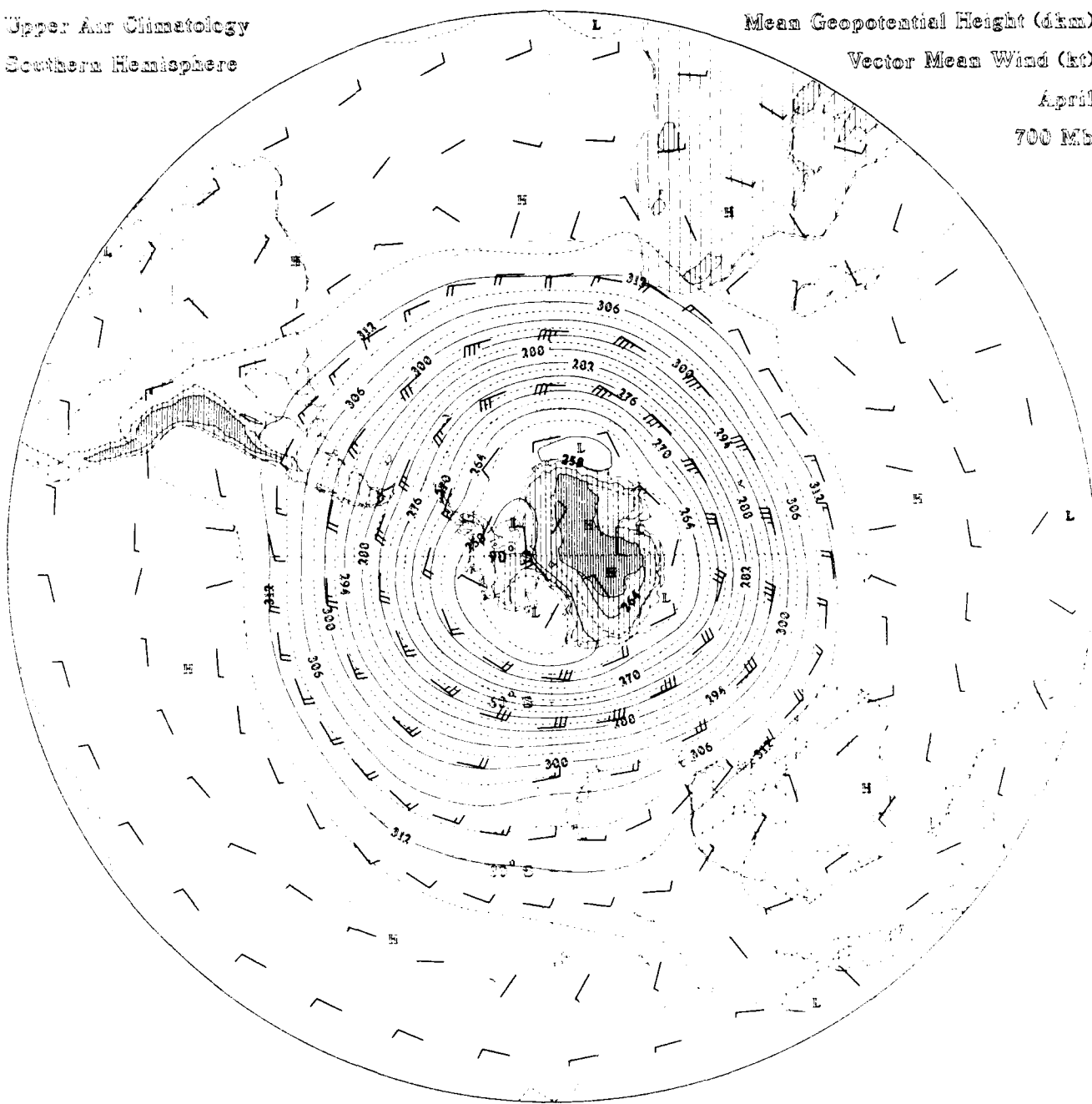
Upper Air Climatology
Southern Hemisphere

Mean Geopotential Height (dkm)

Vector Mean Wind (kt)

April

700 MB



Mean Geopotential Height (dkm)

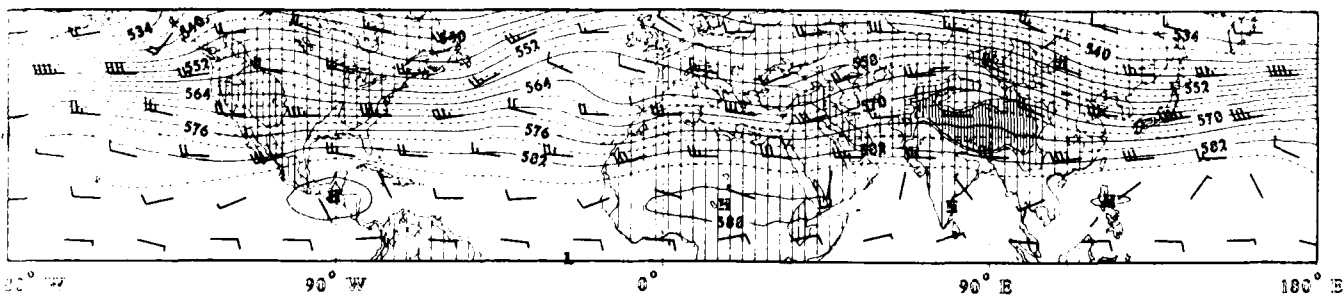
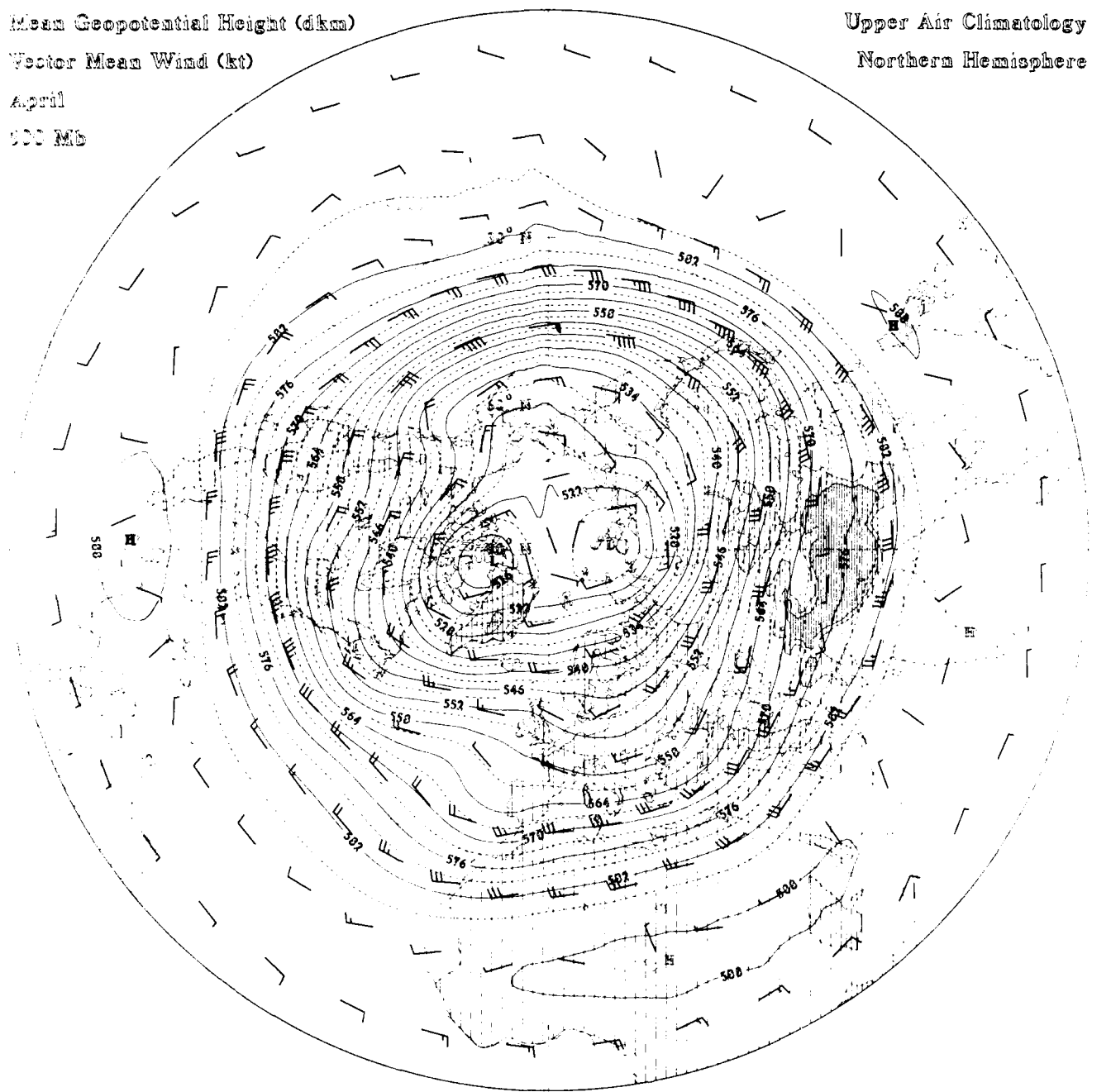
Vector Mean Wind (kt)

April

500 Mb

Upper Air Climatology

Northern Hemisphere



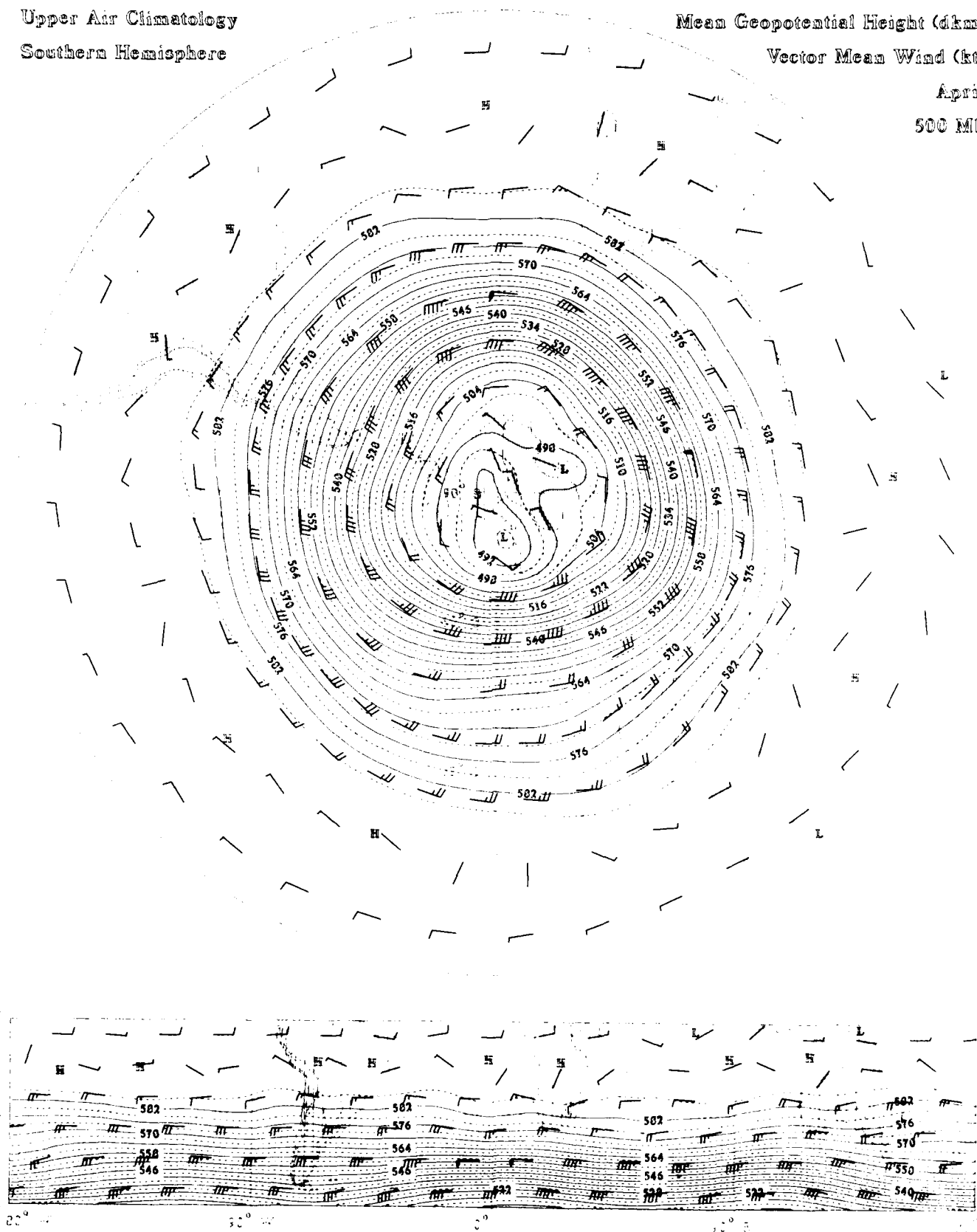
Upper Air Climatology
Southern Hemisphere

Mean Geopotential Height (dkm)

Vector Mean Wind (kt)

April

500 MB



Mean Geopotential Height (dkm)

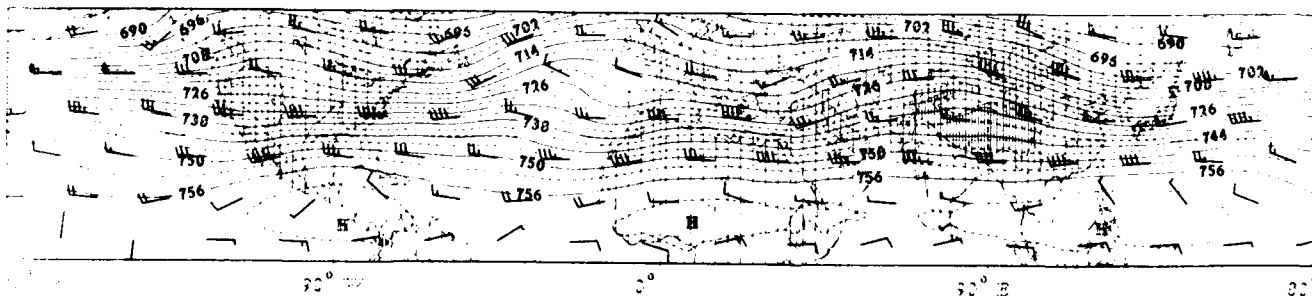
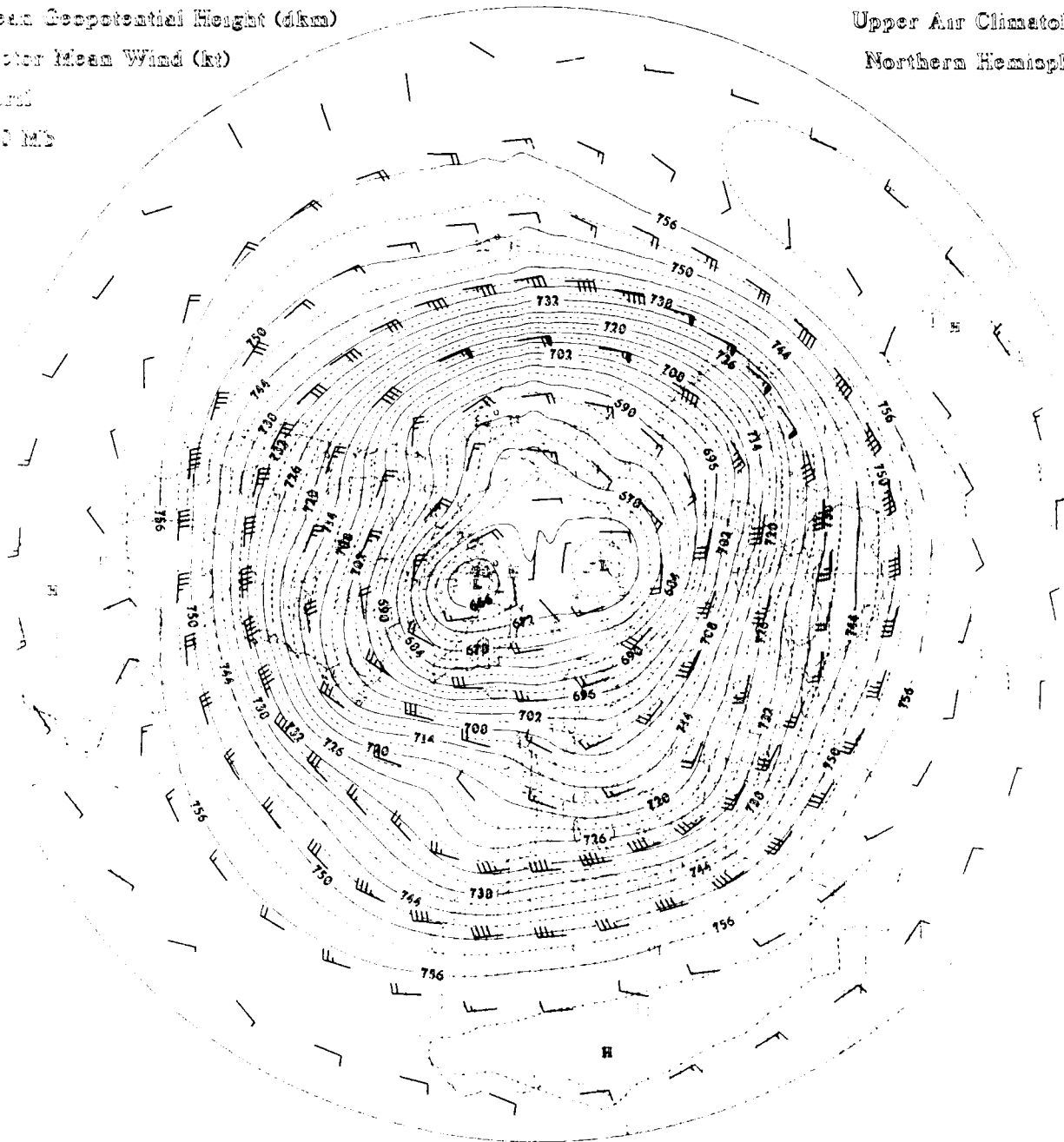
Vector Mean Wind (kt)

April

400 MB

Upper Air Climatology

Northern Hemisphere

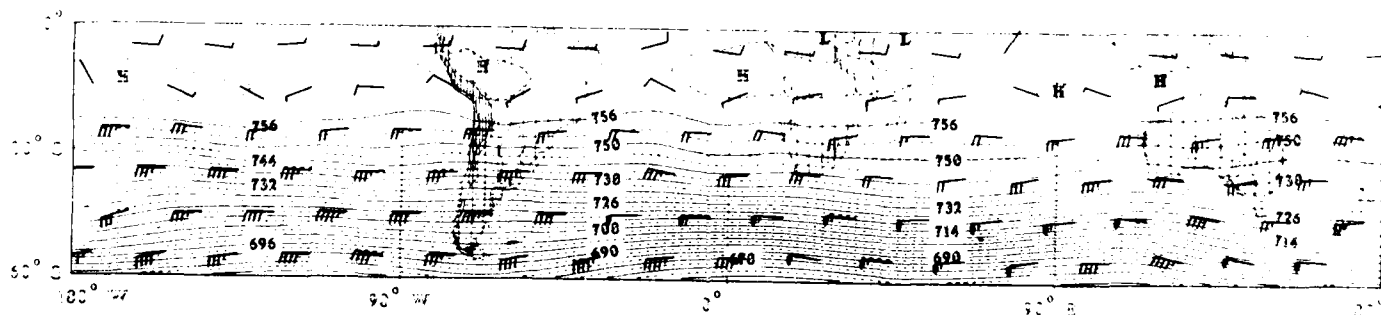
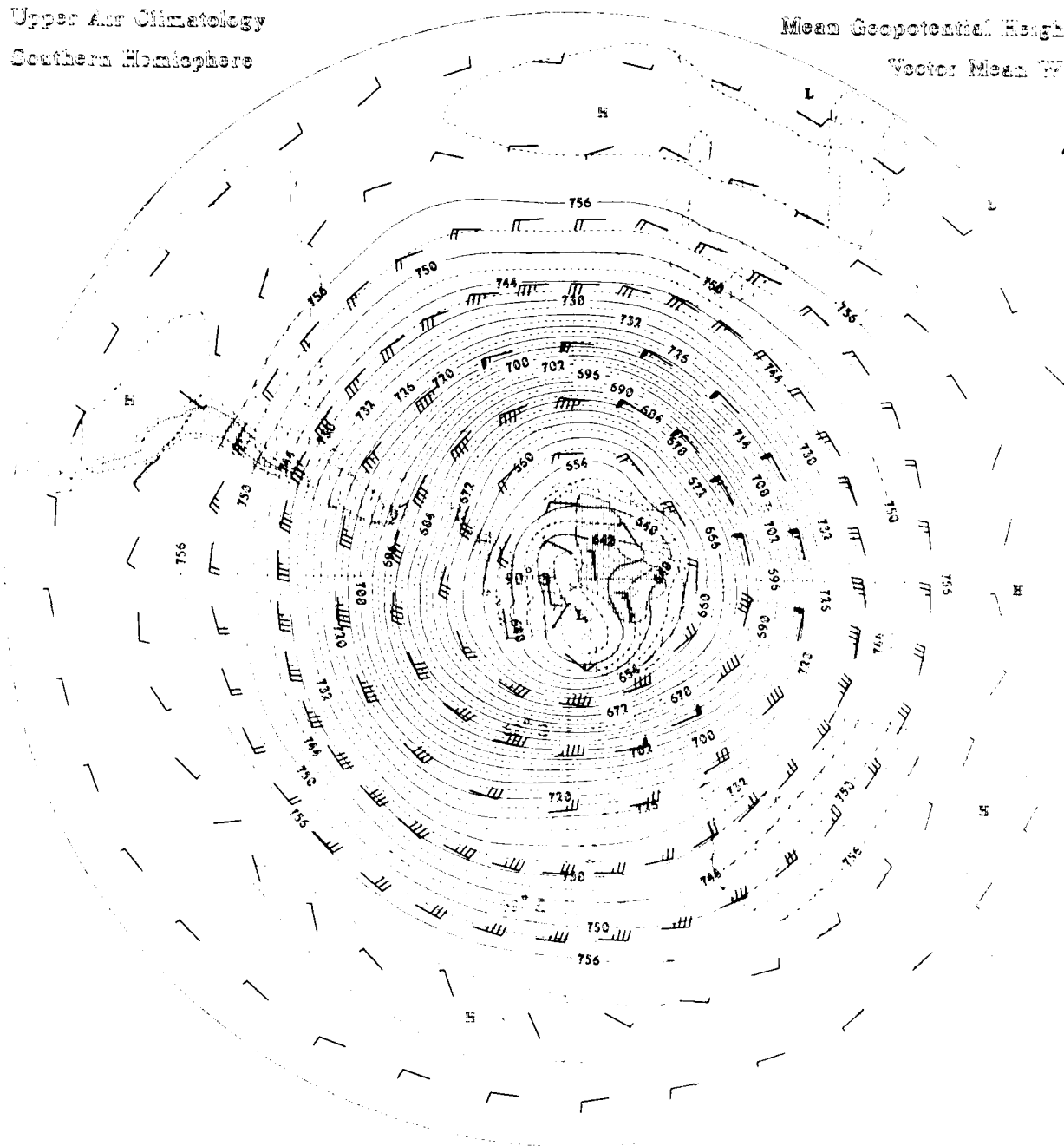


Upper Air Climatology
Southern Hemisphere

Mean Geopotential Height (dam)

Vector Mean Wind (m/s)

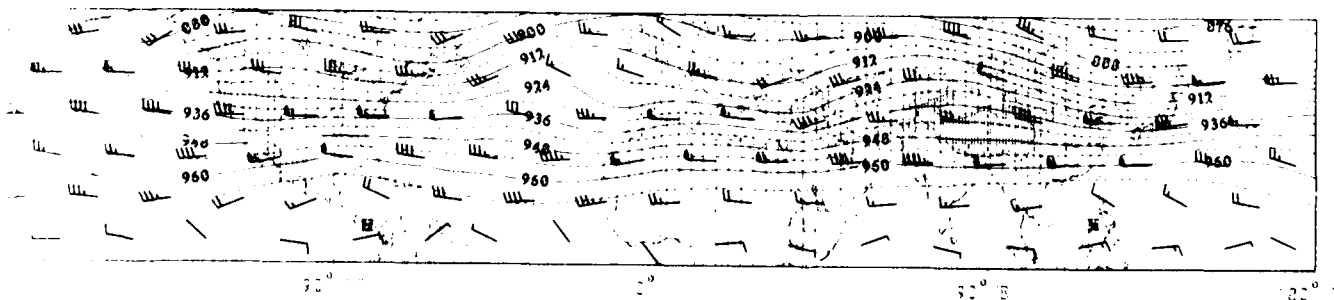
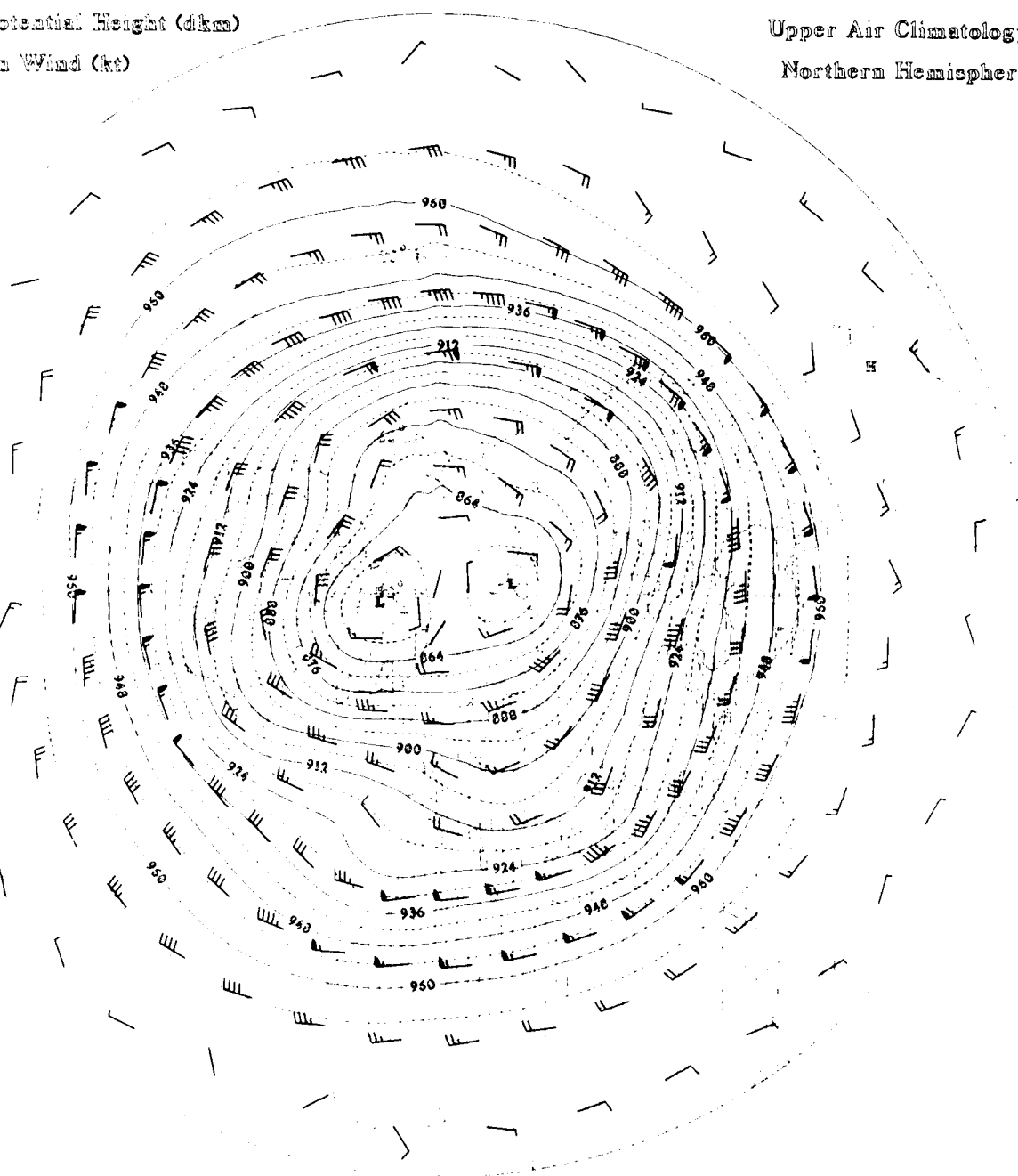
August
1950-1951



Factor Mean Wind (kt)

... MS

Northern Hemisphere



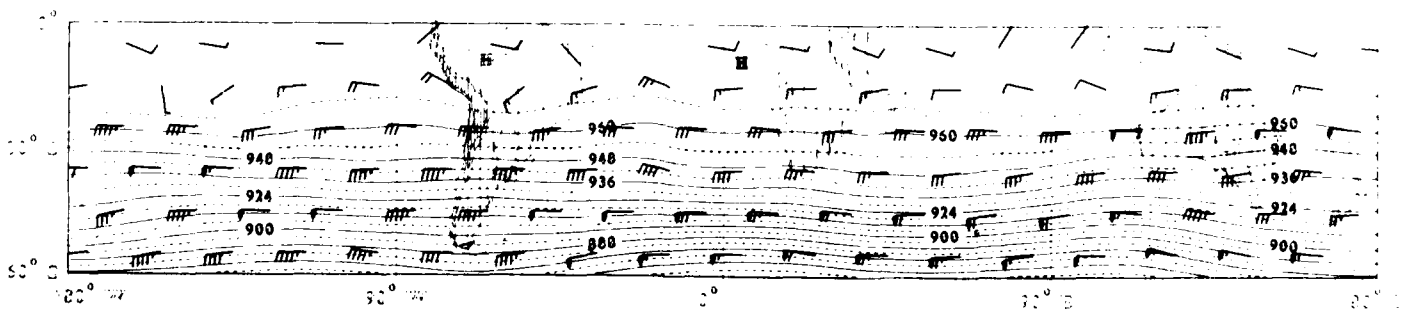
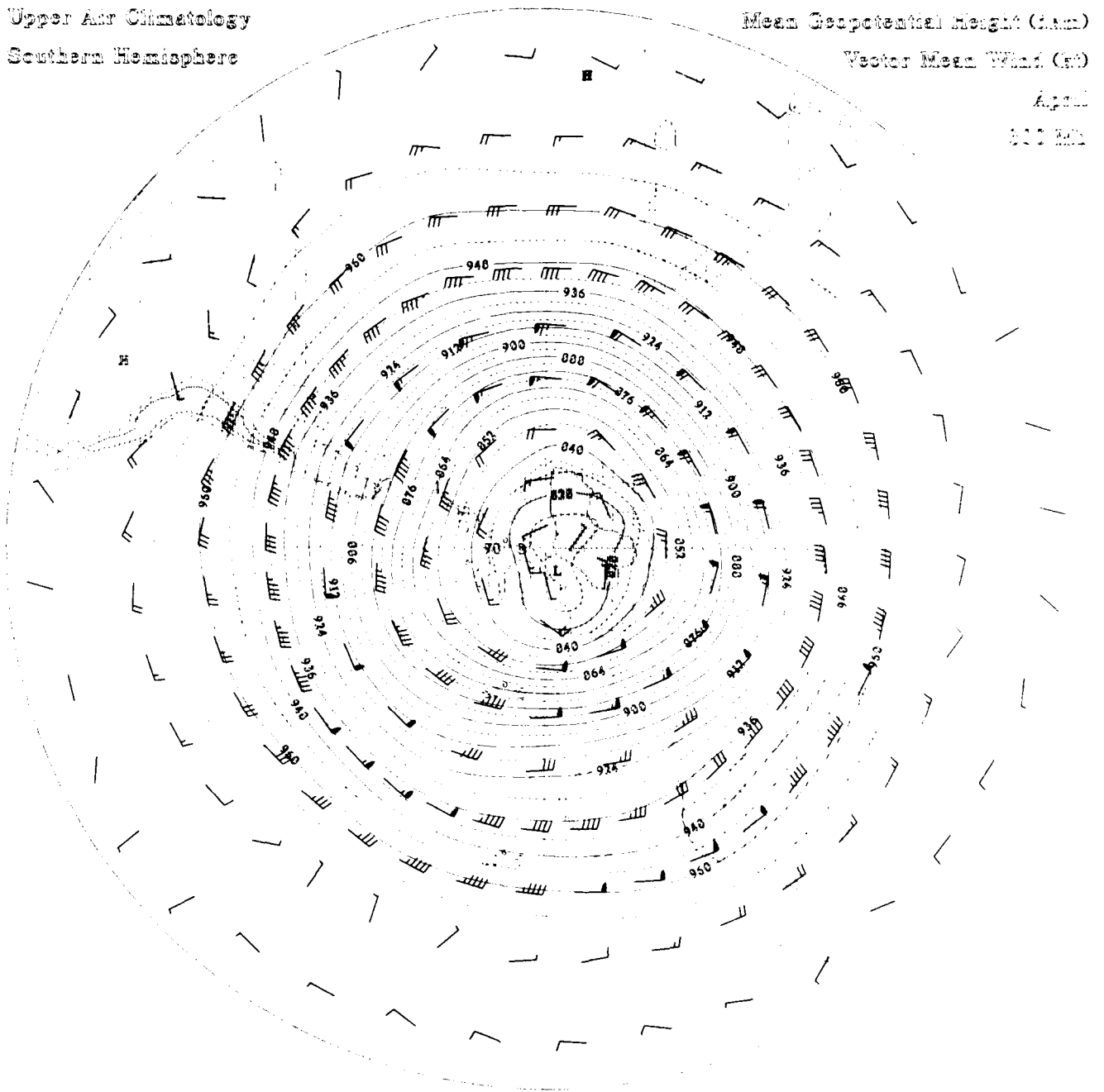
Upper Air Climatology
Southern Hemisphere

Mean Geopotential Height (dam)

Vector Mean Wind (m/s)

April

1971-1980



Mean Geopotential Height (gkm)

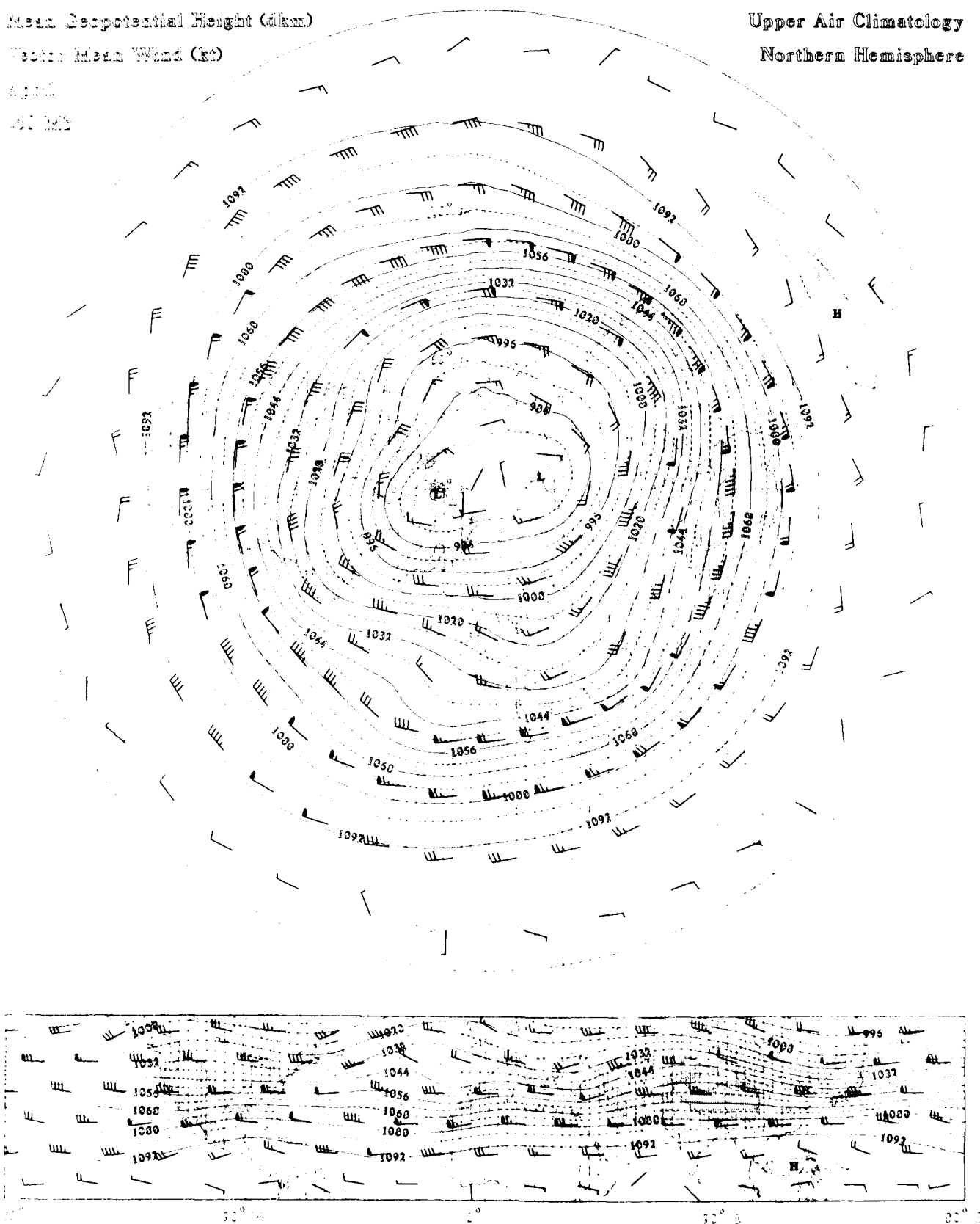
Vector Mean Wind (kt)

April

1950-59

Upper Air Climatology

Northern Hemisphere



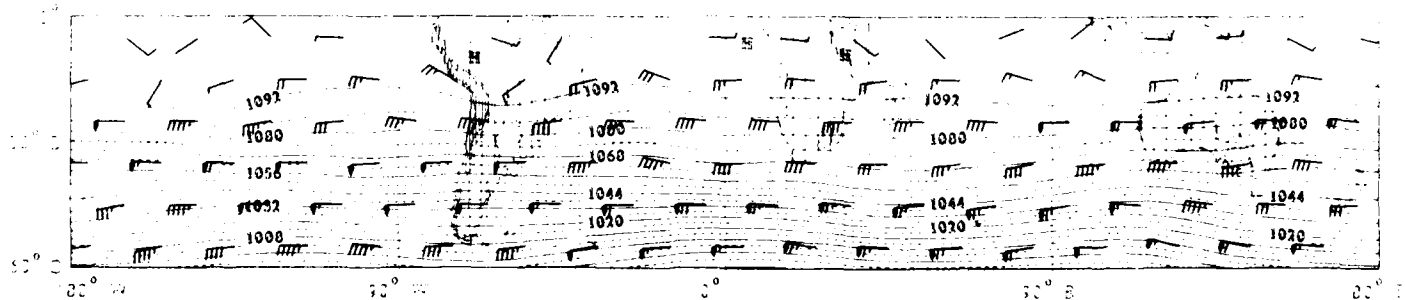
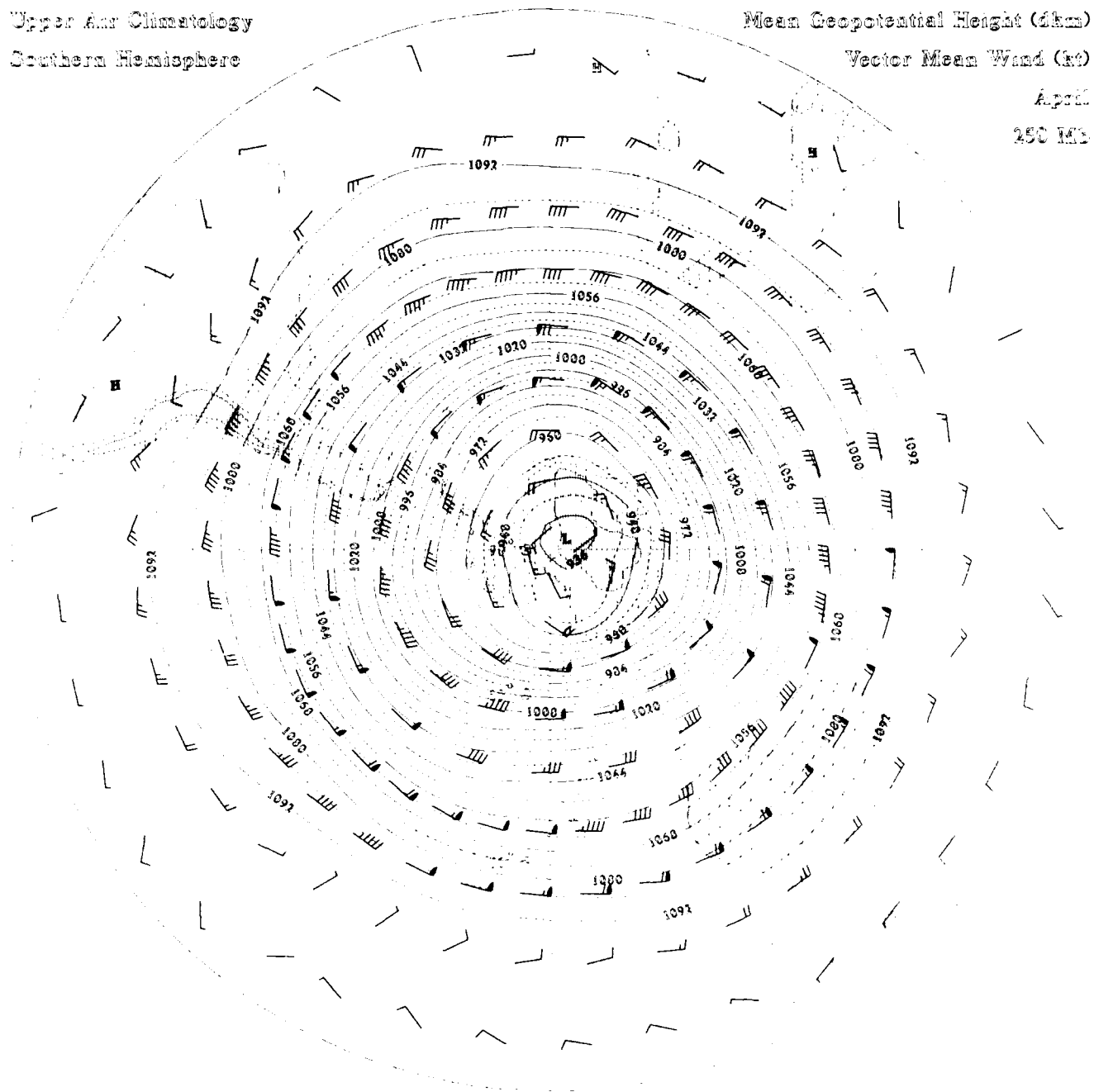
Upper Air Climatology
Southern Hemisphere

Mean Geopotential Height (dkm)

Vector Mean Wind (kt)

April

250 mb



Mean Geopotential Height (dkm)

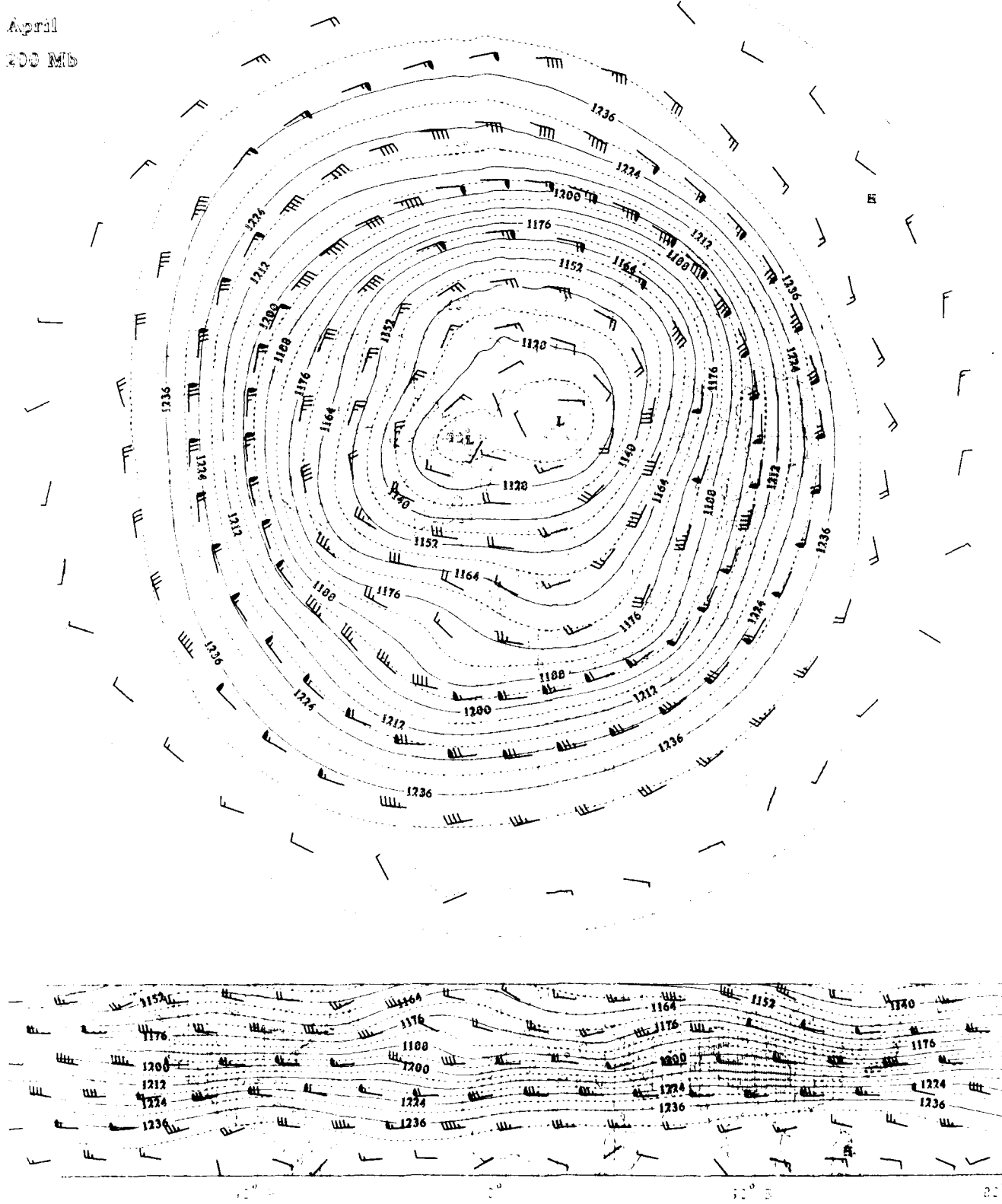
Vector Mean Wind (kt)

April

200 Mb

Upper Air Climatology

Northern Hemisphere



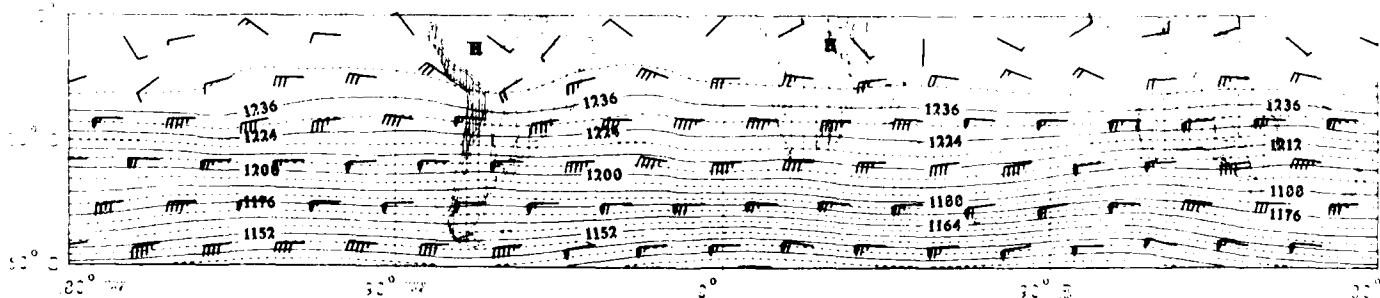
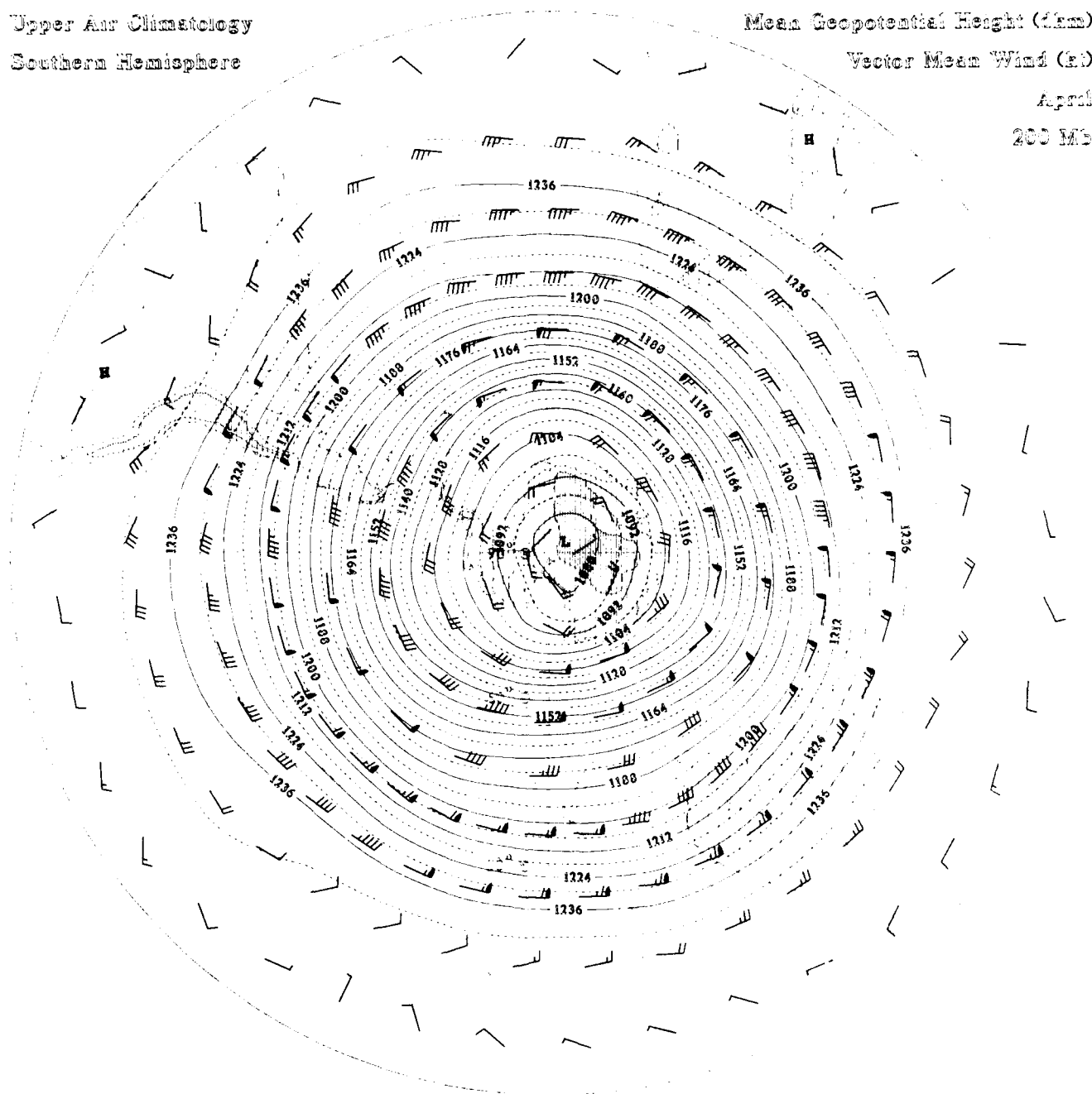
Upper Air Climatology
Southern Hemisphere

Mean Geopotential Height (dam)

Vector Mean Wind (m)

April

200 MB



Mean Depthwise Range (mm)

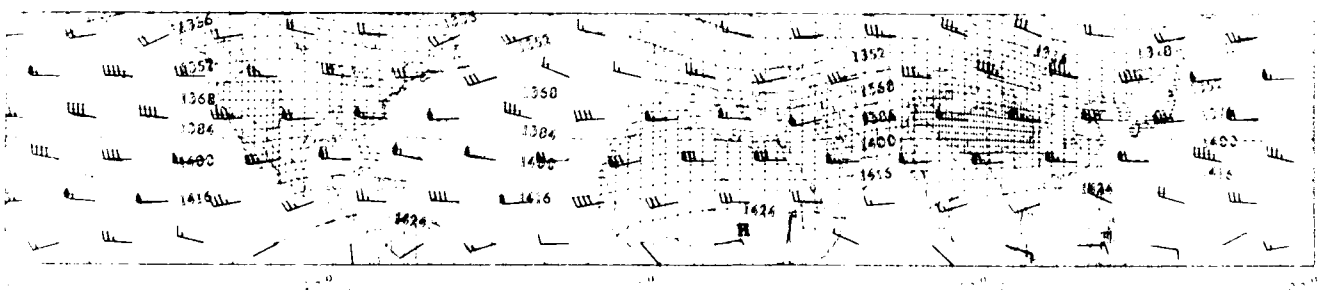
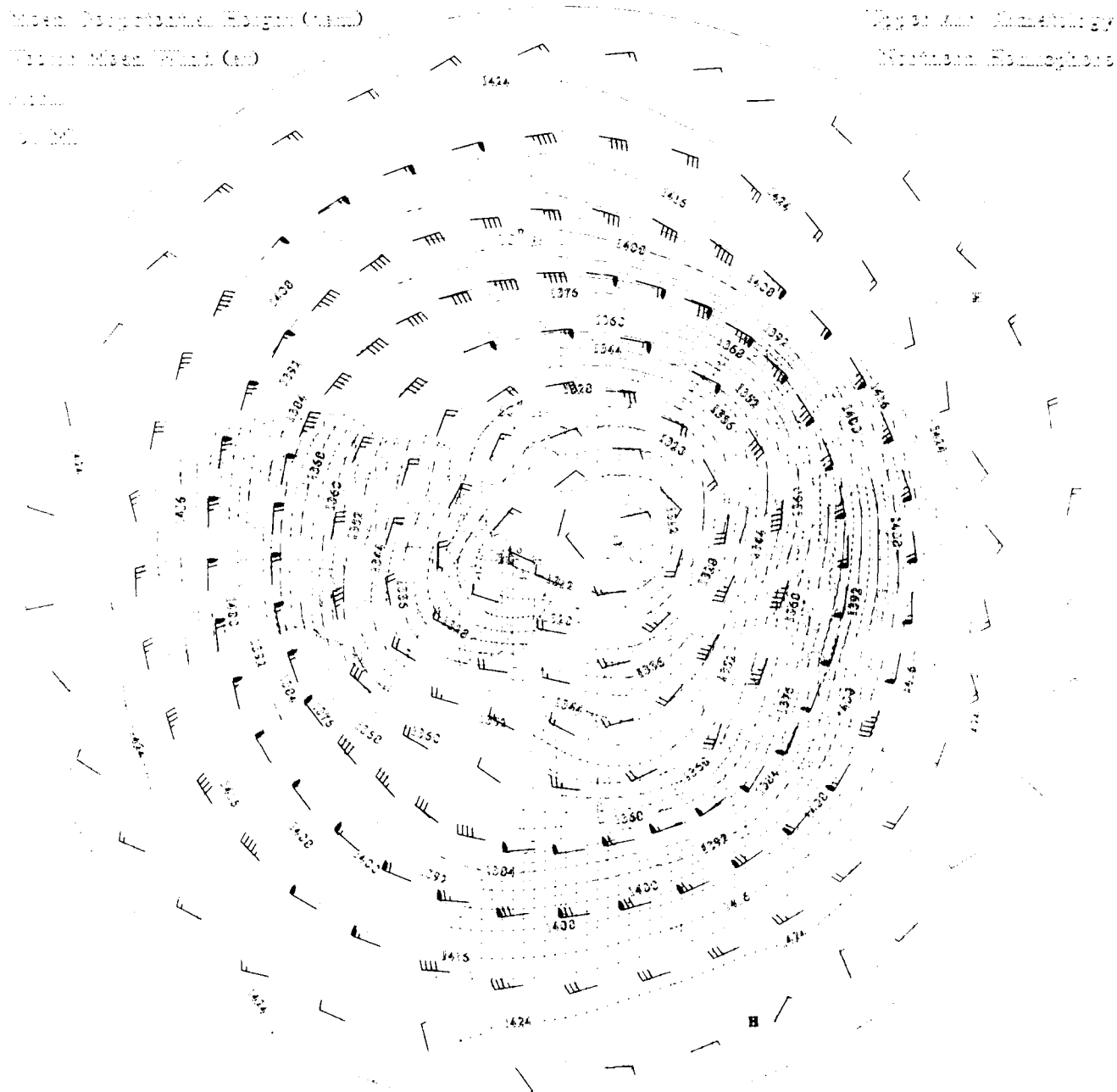
Time Mean Wind (m)

1111

1111

Top 30 km Soundings

Western Hemisphere



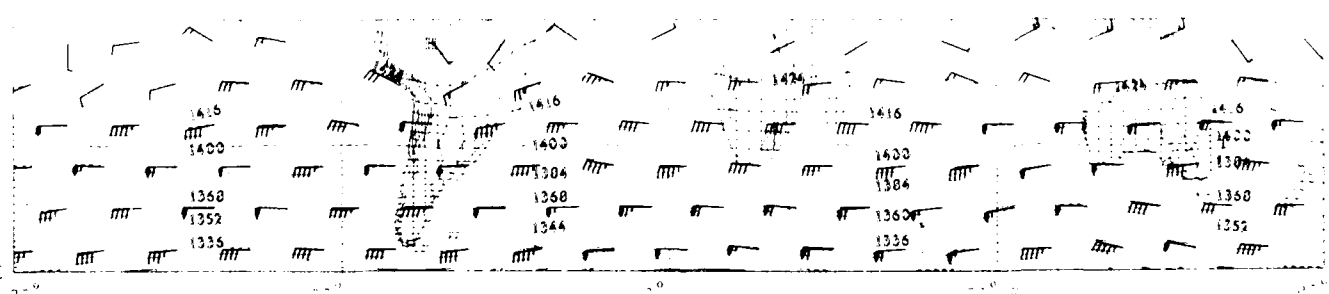
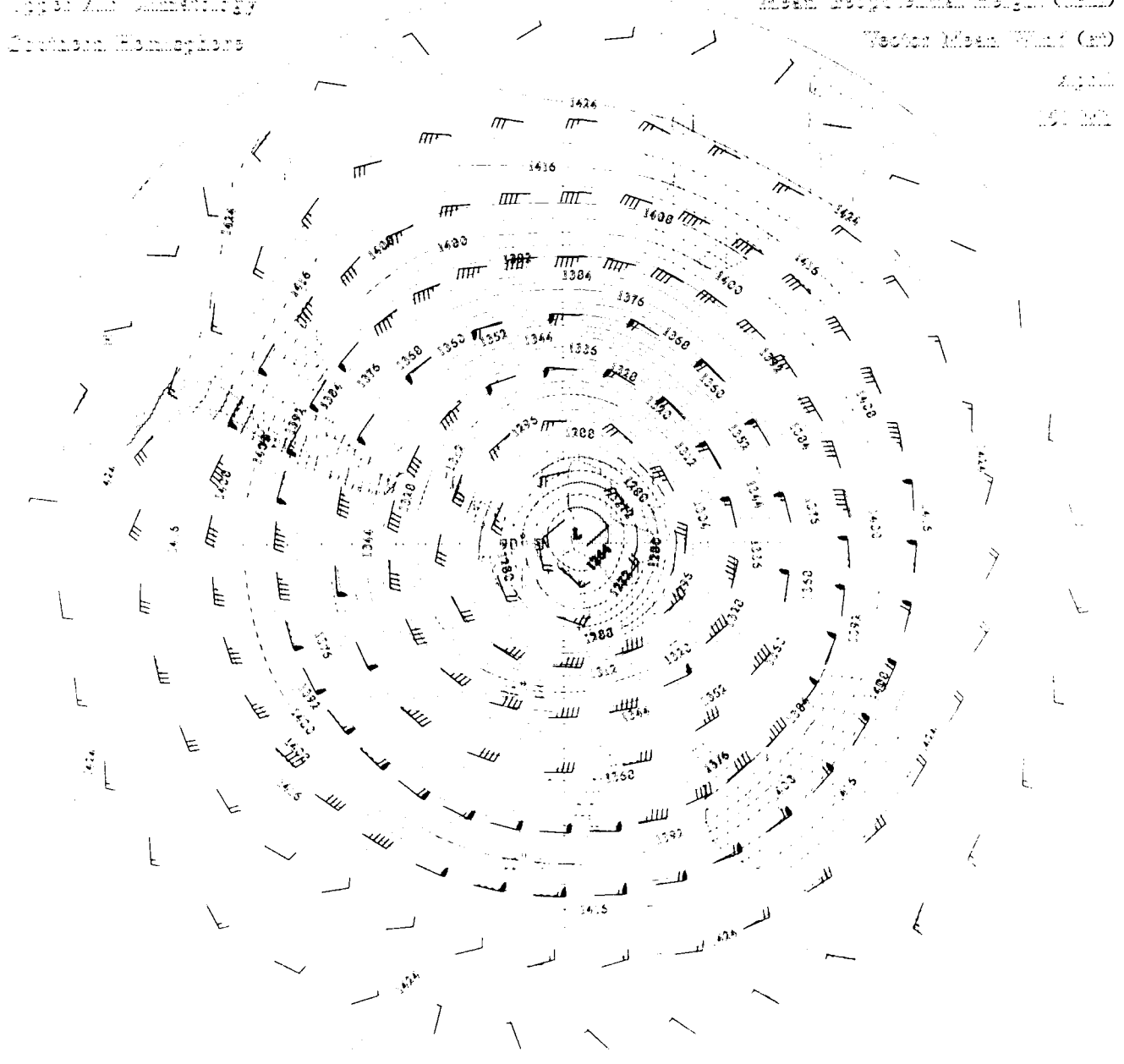
Topographic Contouring
 Geometric Homophony

Mean Geopotential Height (m)

Vector Mean Wind (m)

1000

1000



Mean Geopotential Height (GPM)

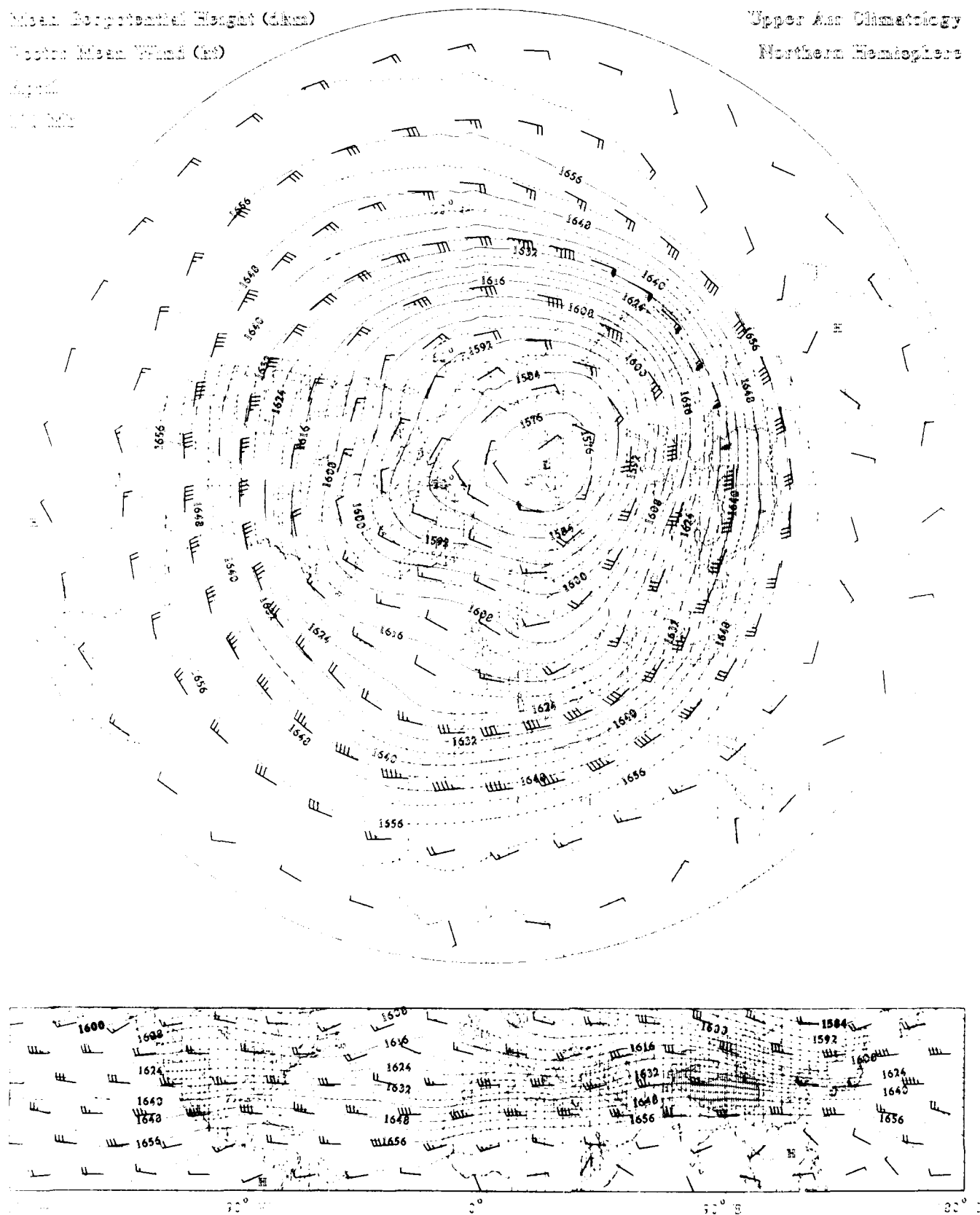
Vector Mean Wind (m/s)

April

1971-1972

Upper Air Climatology

Northern Hemisphere



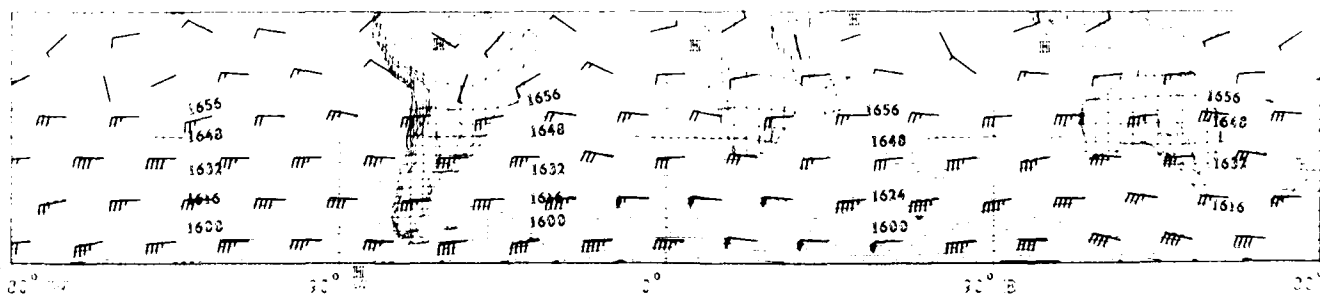
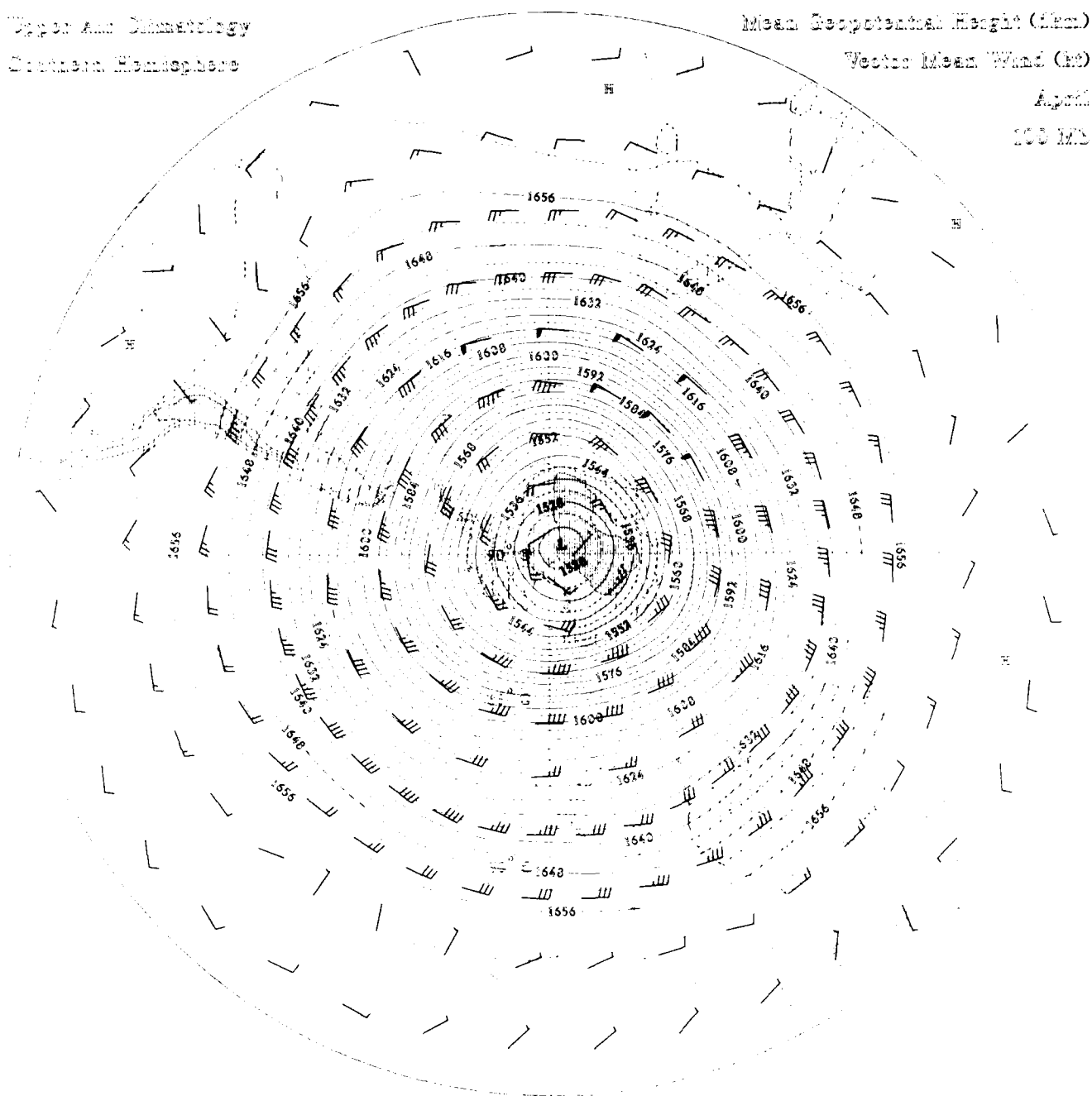
Upper Air Synoptology
 Northern Hemisphere

Mean Geopotential Height (dam)

Vector Mean Wind (kt)

April

100 MB



Mean Geopotential Height (dam)

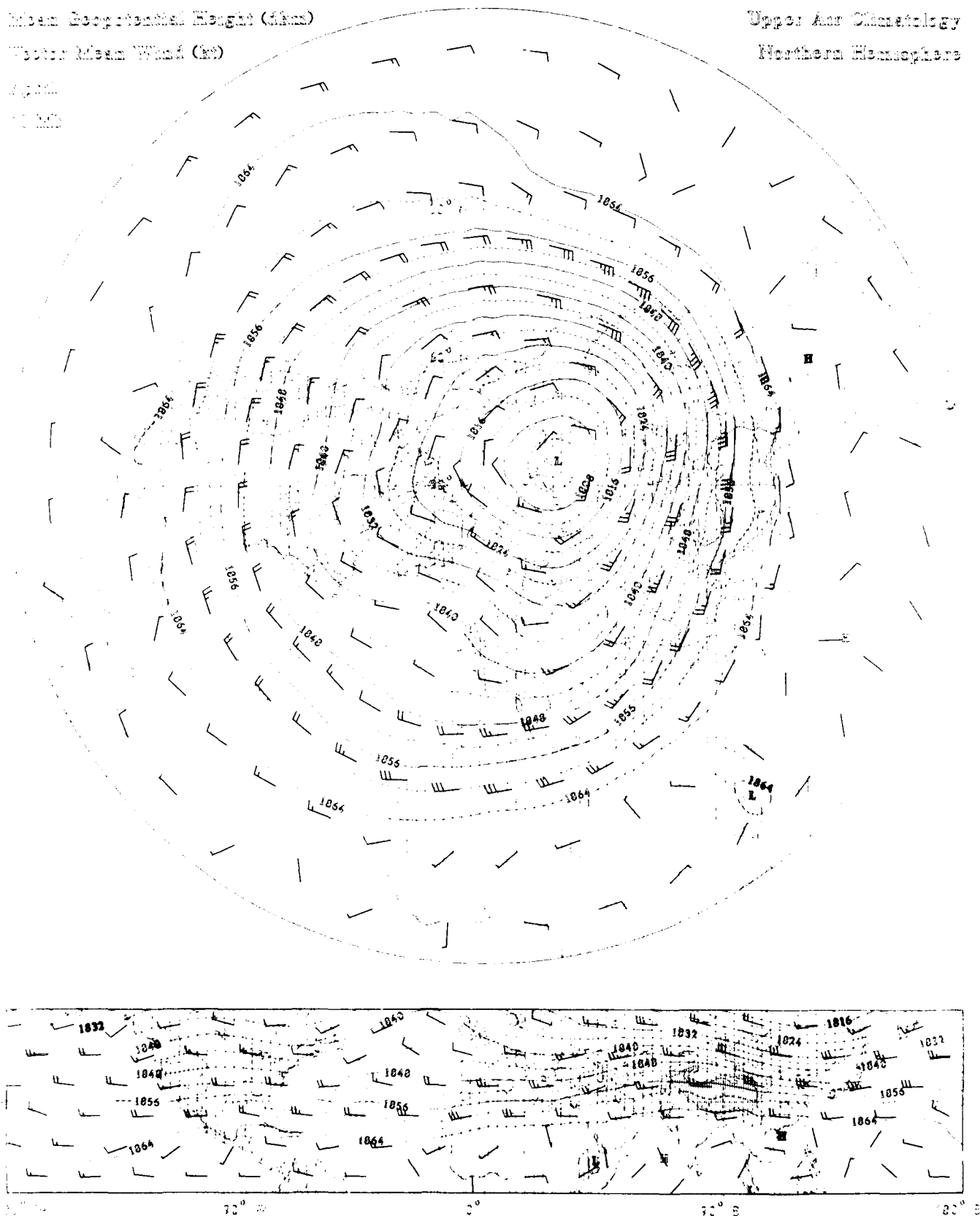
Vector Mean Wind (kt)

April

1960

Upper Air Climatology

Northern Hemisphere



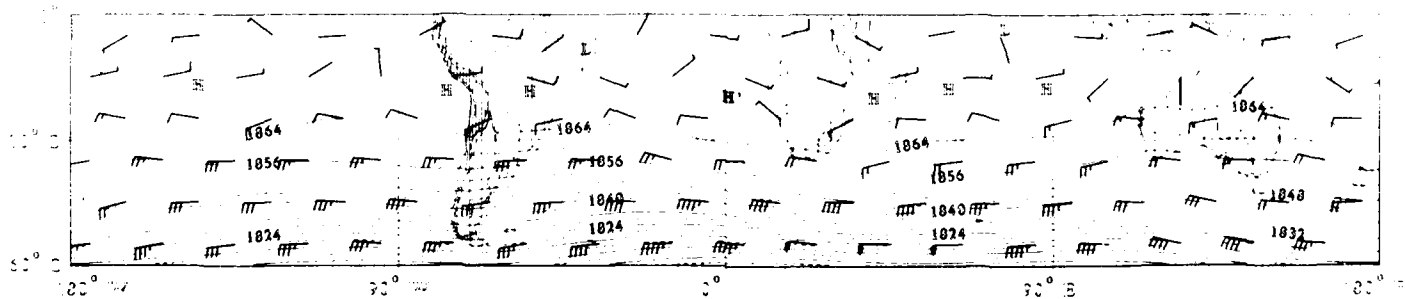
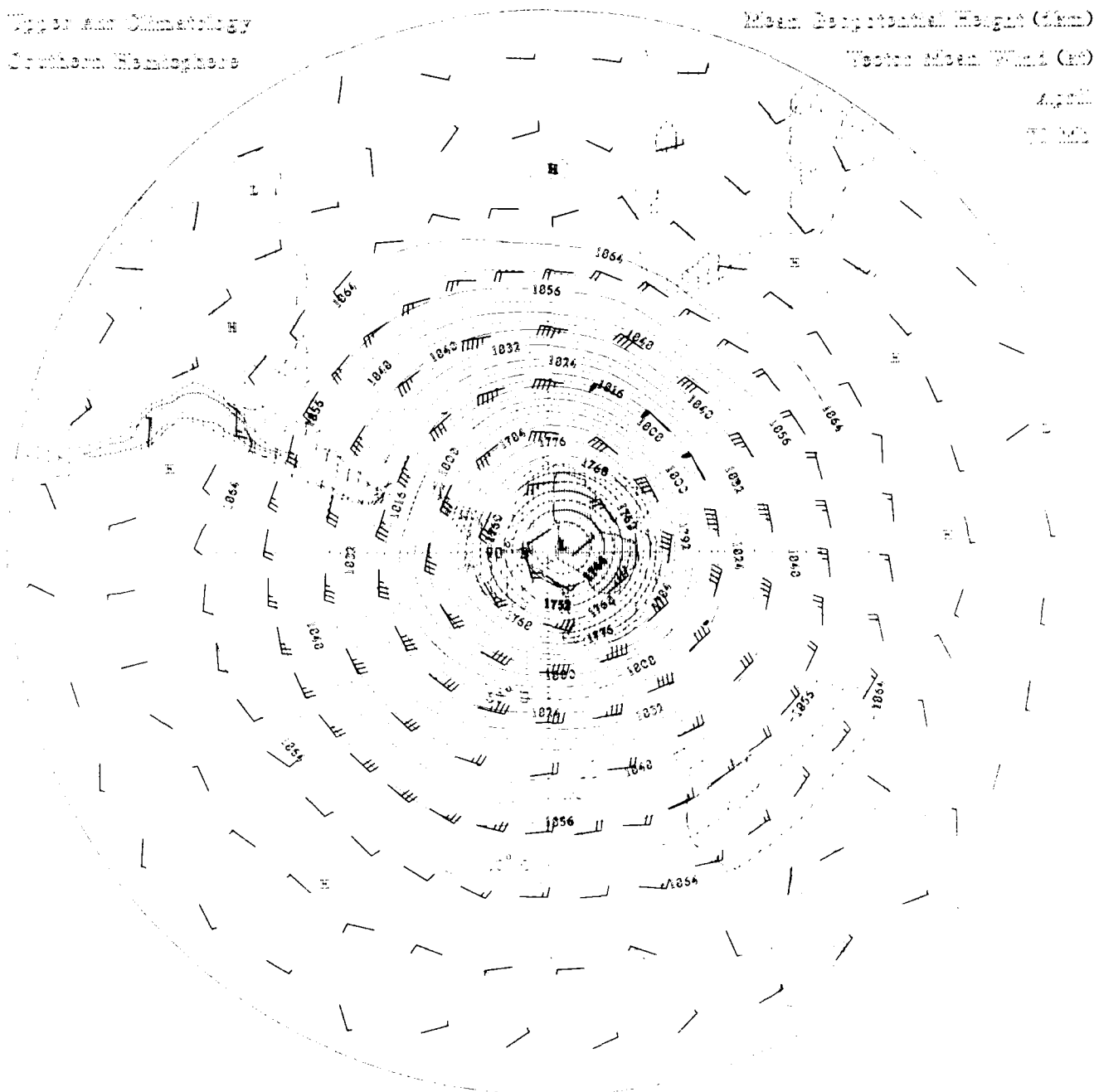
SECRET

Notes: Dispersal: High (40%)

Topic: Algebra (25)

Acknowledgments

$\frac{d}{dt} \left(\frac{\partial L}{\partial \dot{x}} \right) = \frac{\partial L}{\partial x}$



Mean Geopotential Height (ghm)

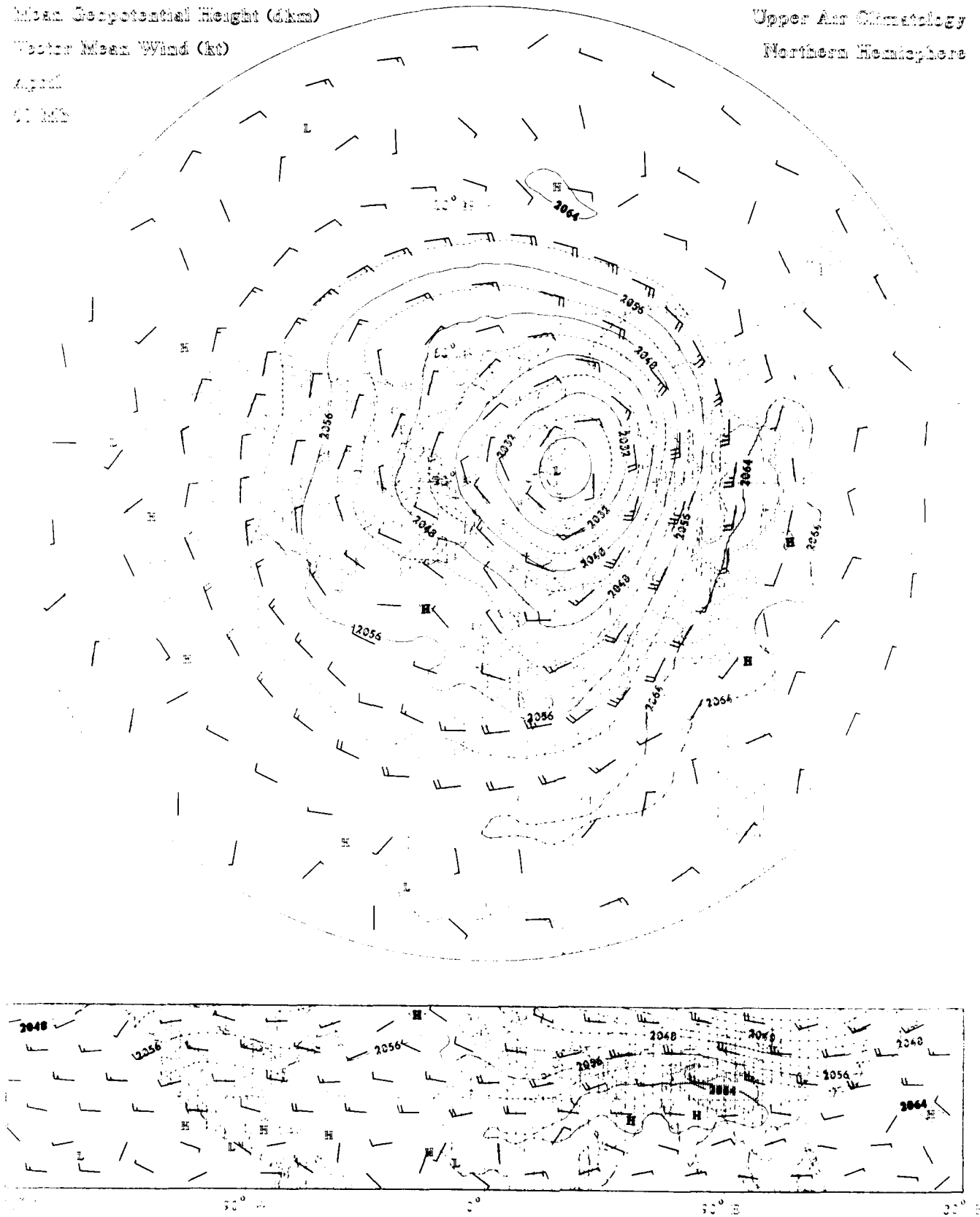
Vector Mean Wind (kt)

April

01 00Z

Upper Air Climatology

Northern Hemisphere



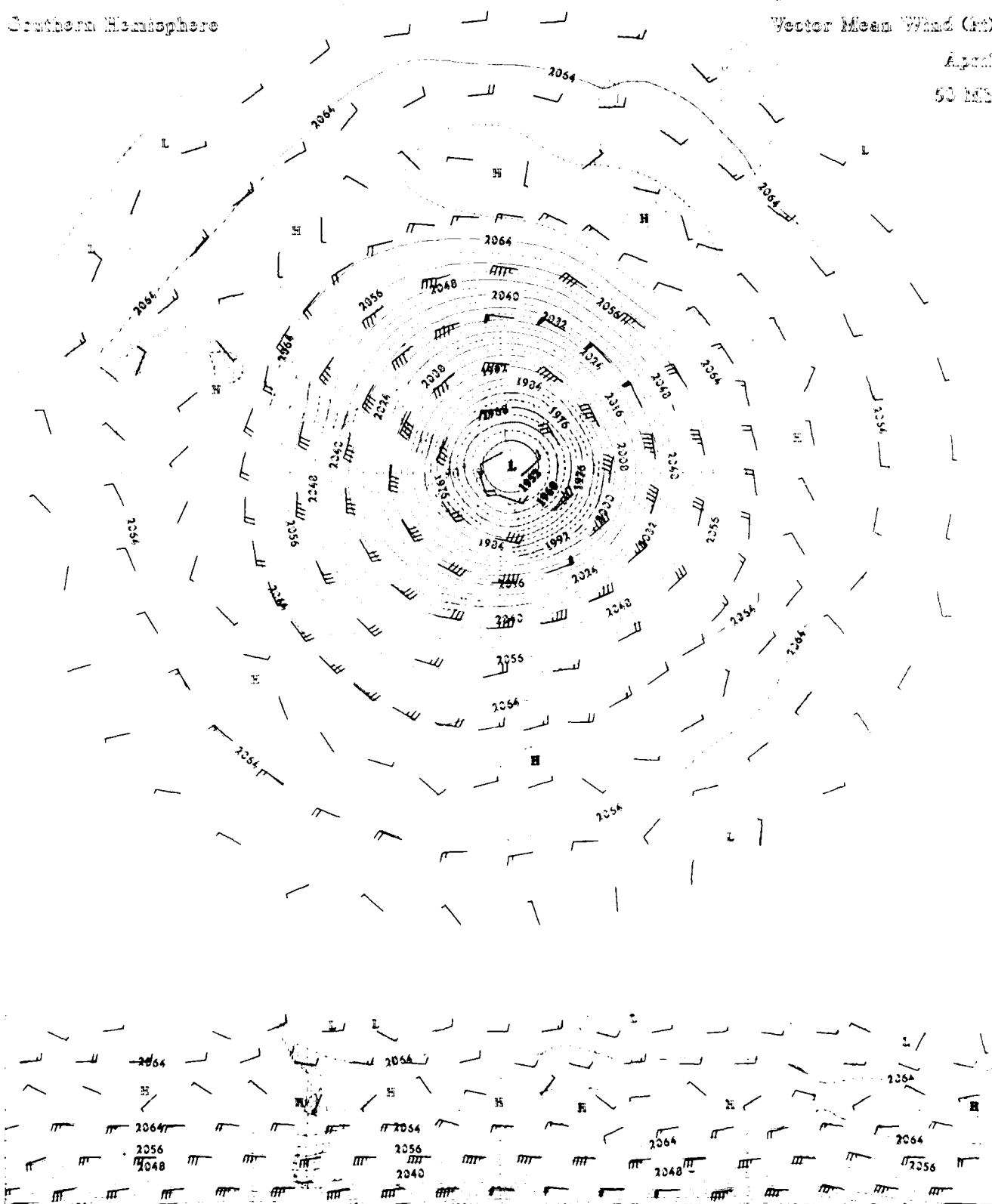
Upper Air Climatology
Southern Hemisphere

Mean Geopotential Height (gpm)

Vector Mean Wind (kt)

April

50 mb



Mean Geopotential Height (ghm)

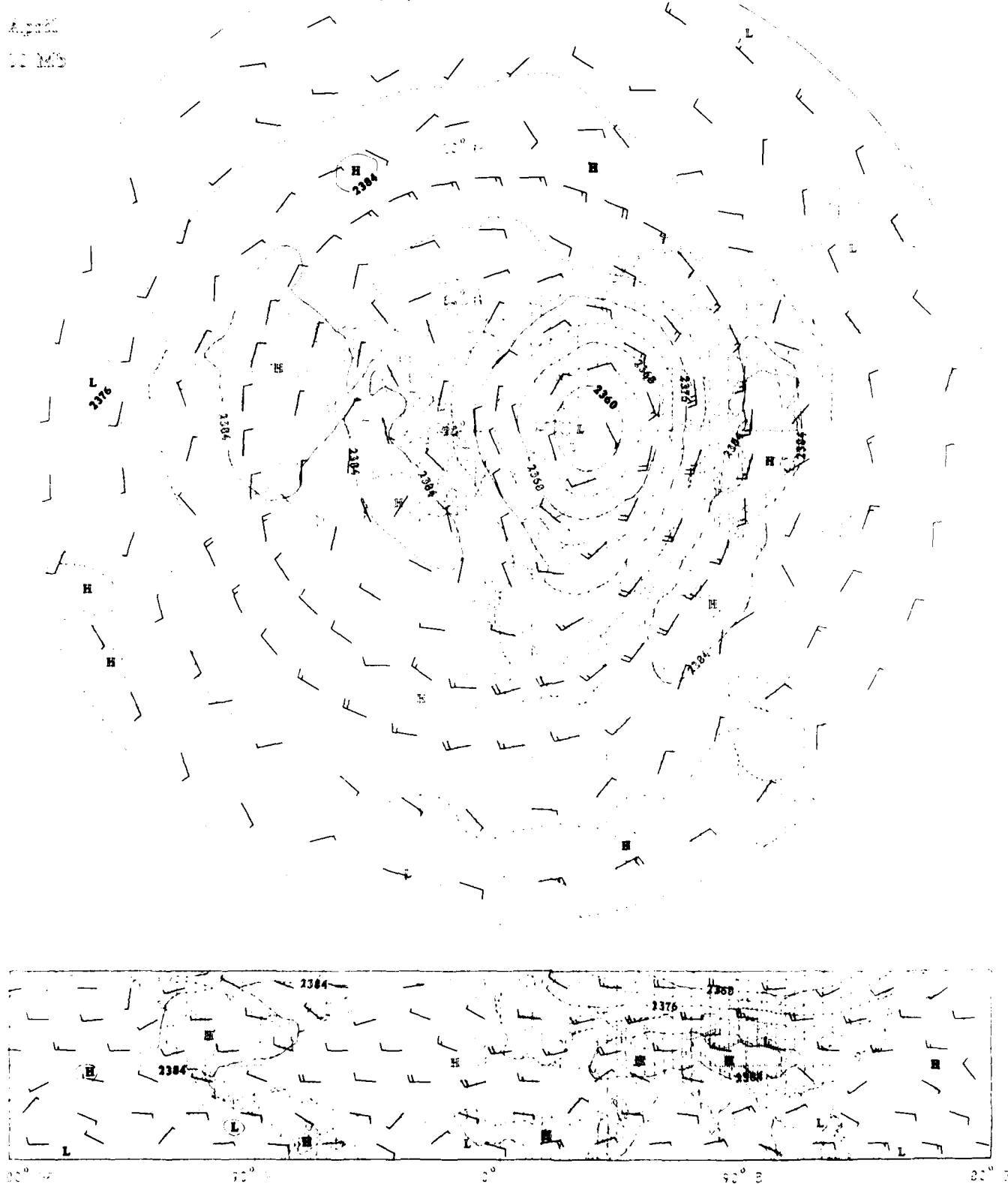
Vector Mean Wind (kt)

April

11 MB

Upper Air Climatology

Northern Hemisphere



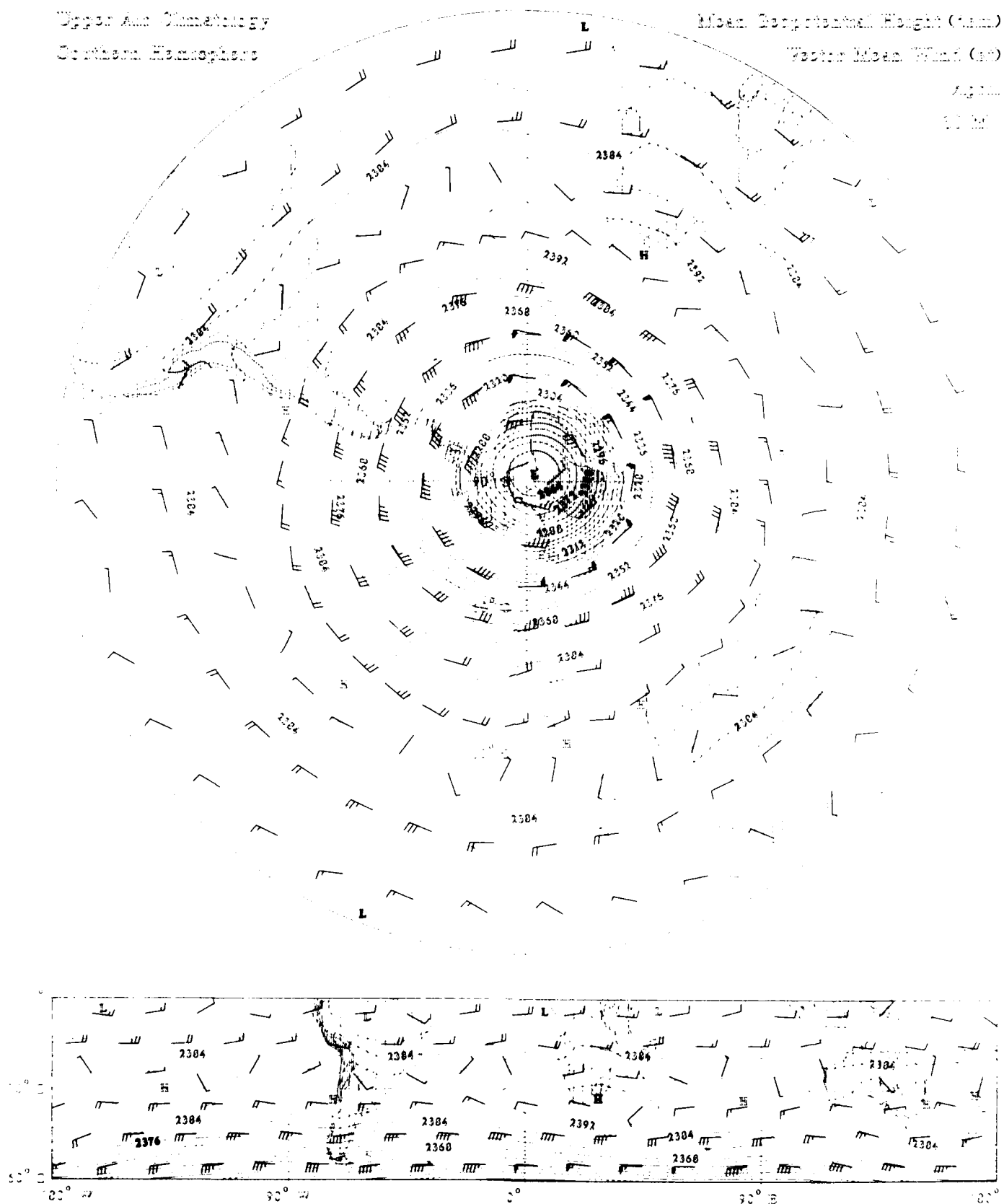
Upper Air Climatology
 Southern Hemisphere

Mean Geopotential Height (dam)

Vector Mean Wind (m/s)

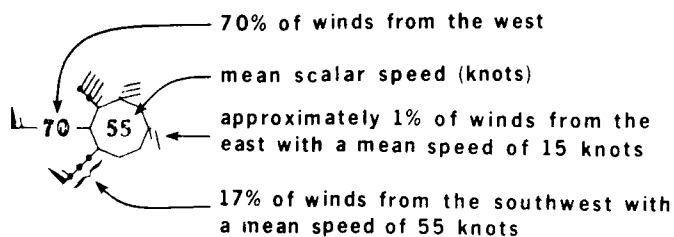
1 gpm

10 km

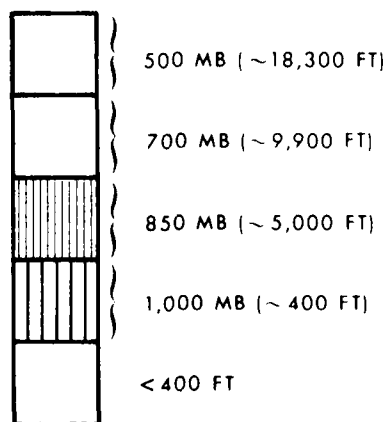


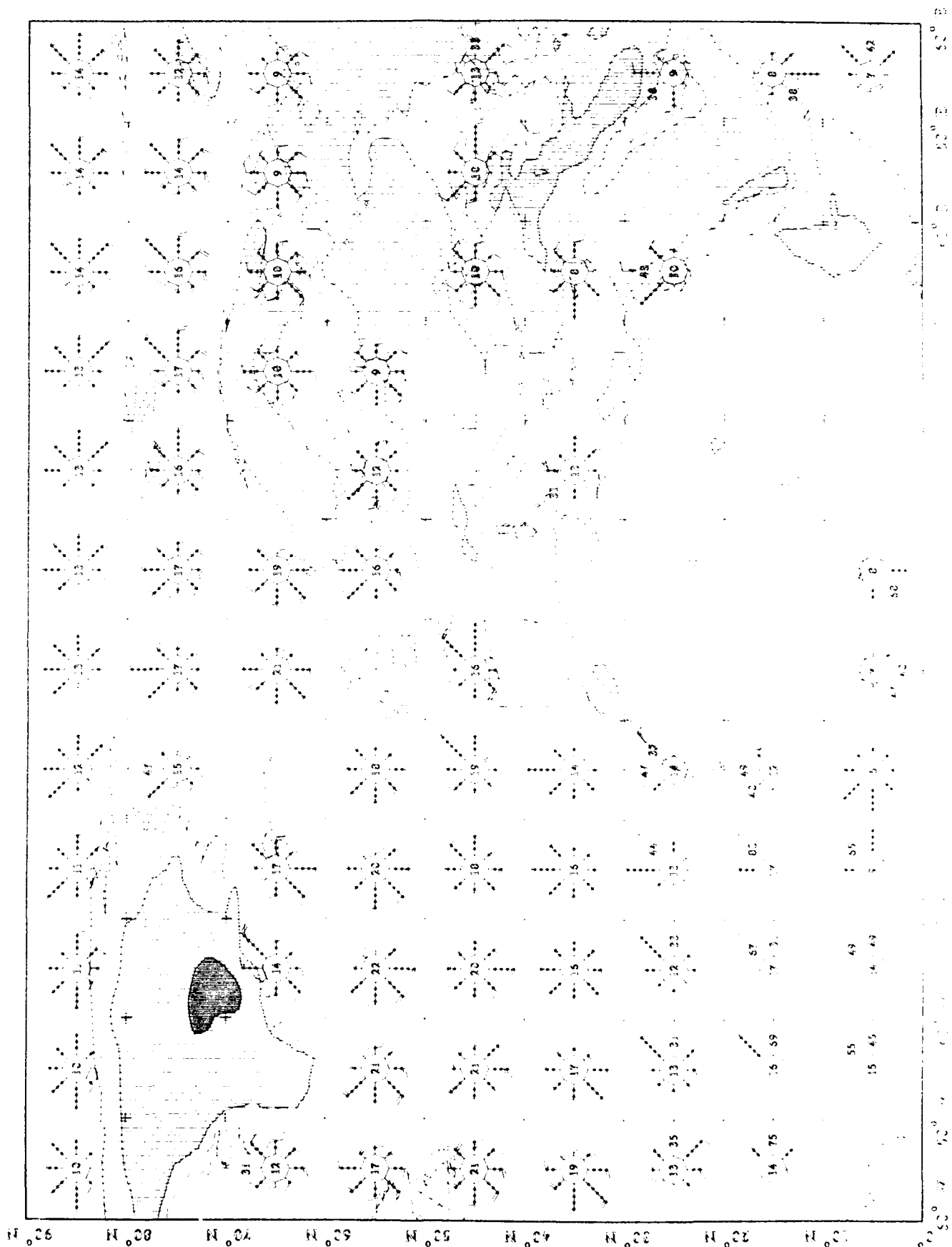
WIND ROSES (13 LEVELS, 1000 TO 30 MB)

- Wind roses at 10 degree latitude/longitude grid points
- Directional mean wind speed in 5 knot increments
- Frequency proportional to barb length with individual dots representing 5% increments. Values greater than 30% are plotted directly on the barb.
- Roses blanked at grid points with elevations exceeding specified geopotential heights.
- Sample rose explanation:



ELEVATION SCALE





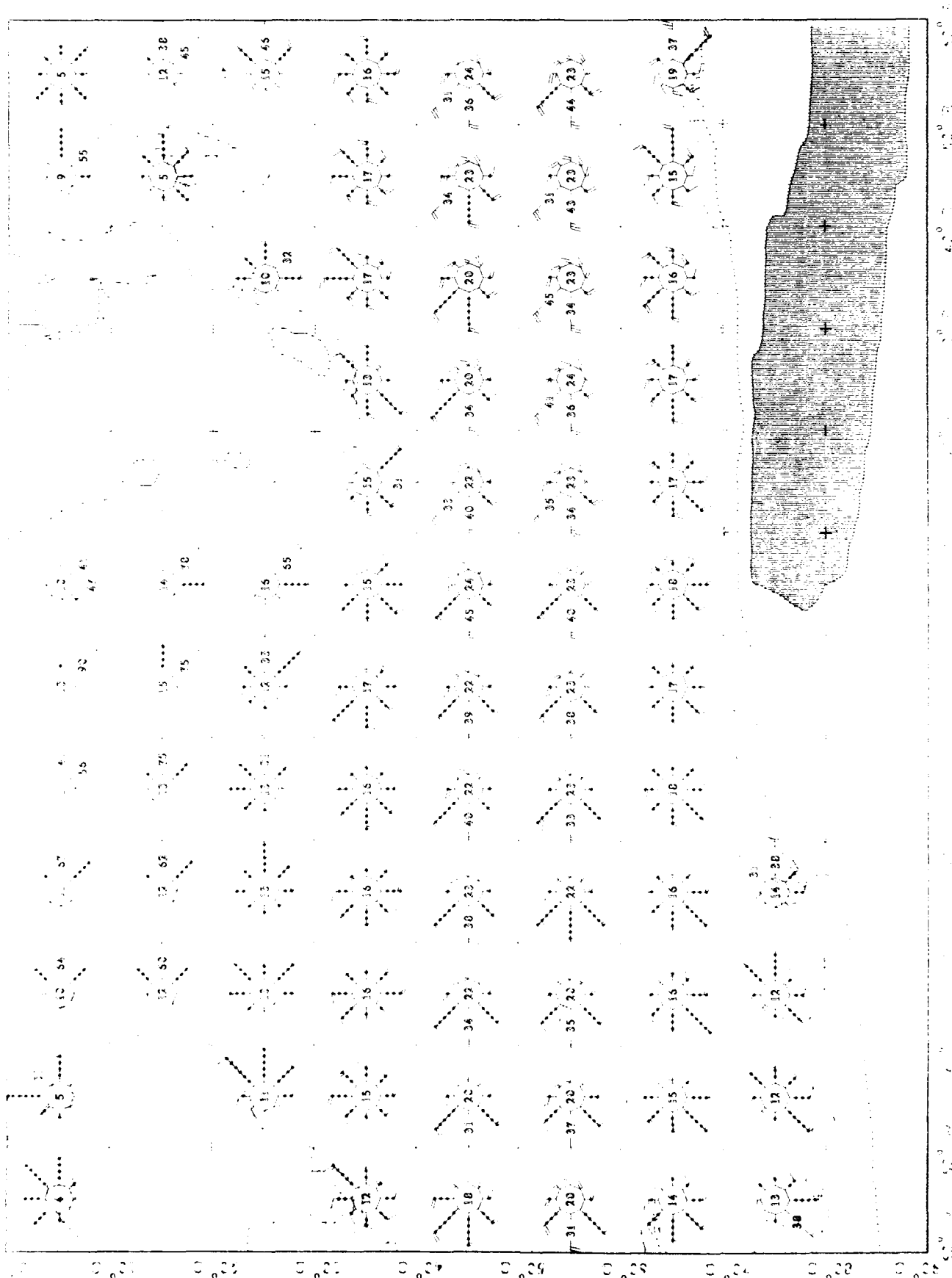
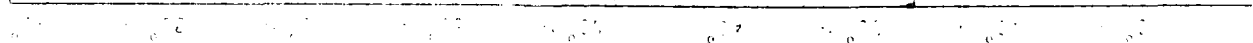


Figure 1. Hawaiian Islands
 (Continued)



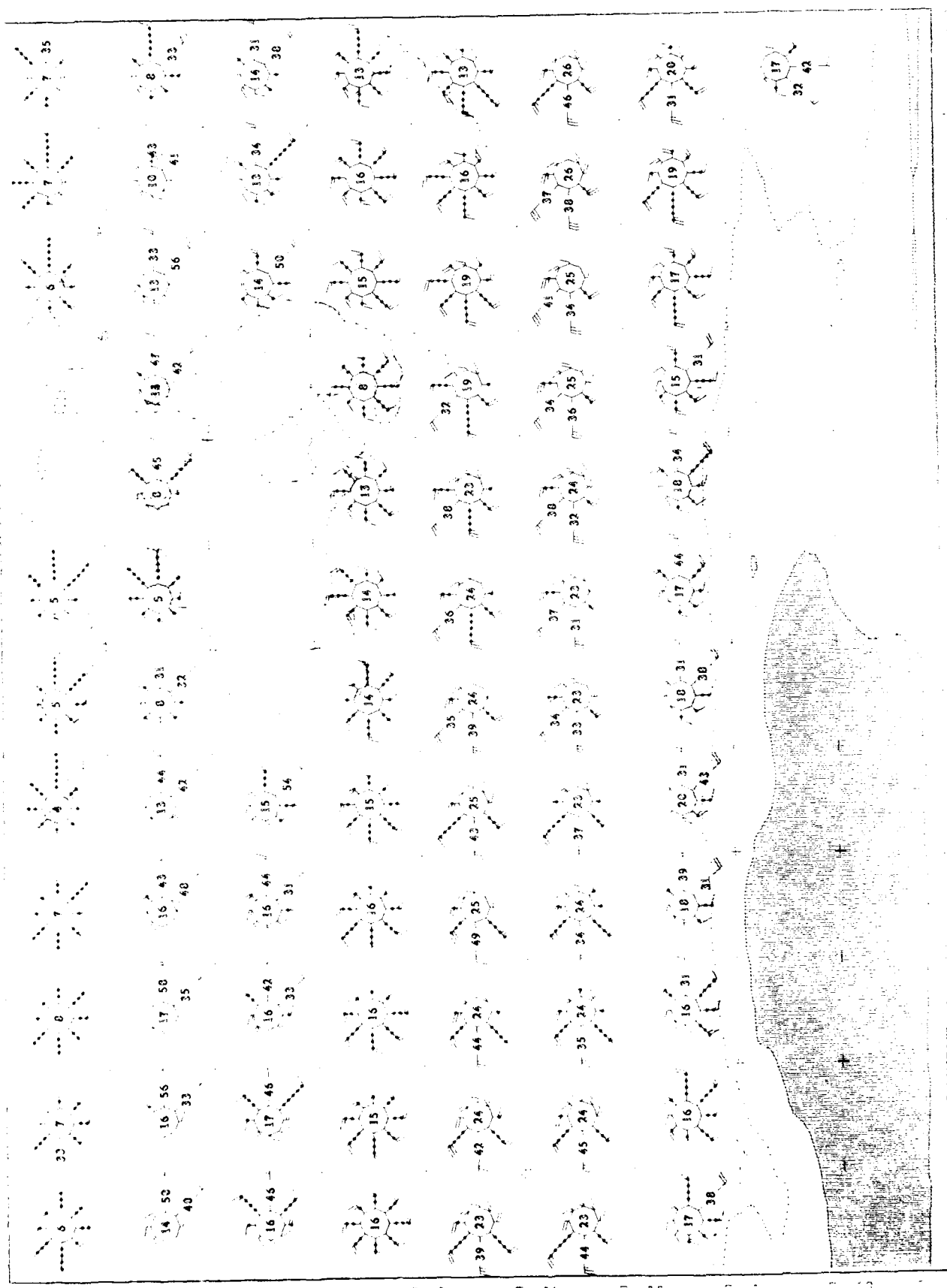
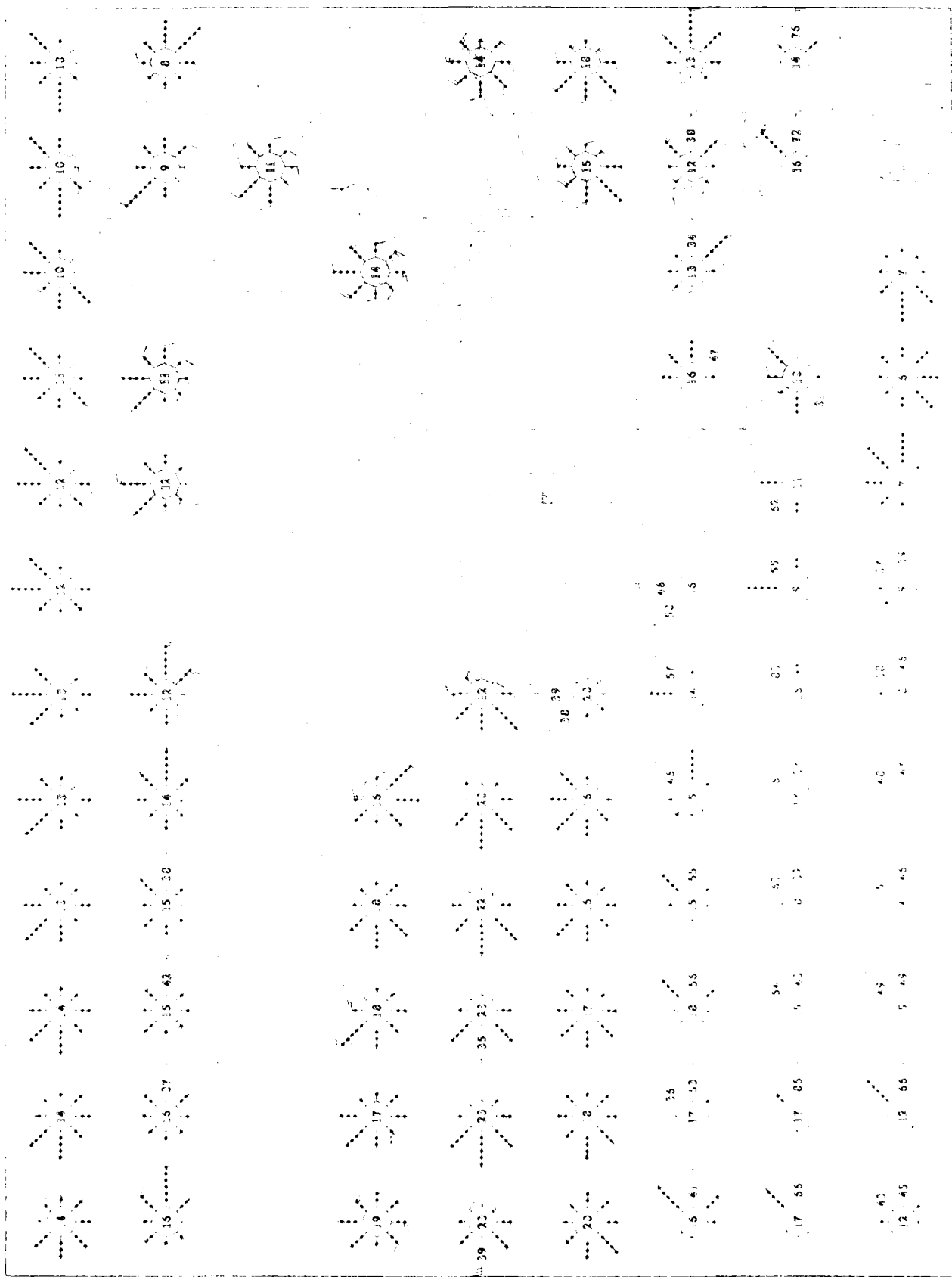
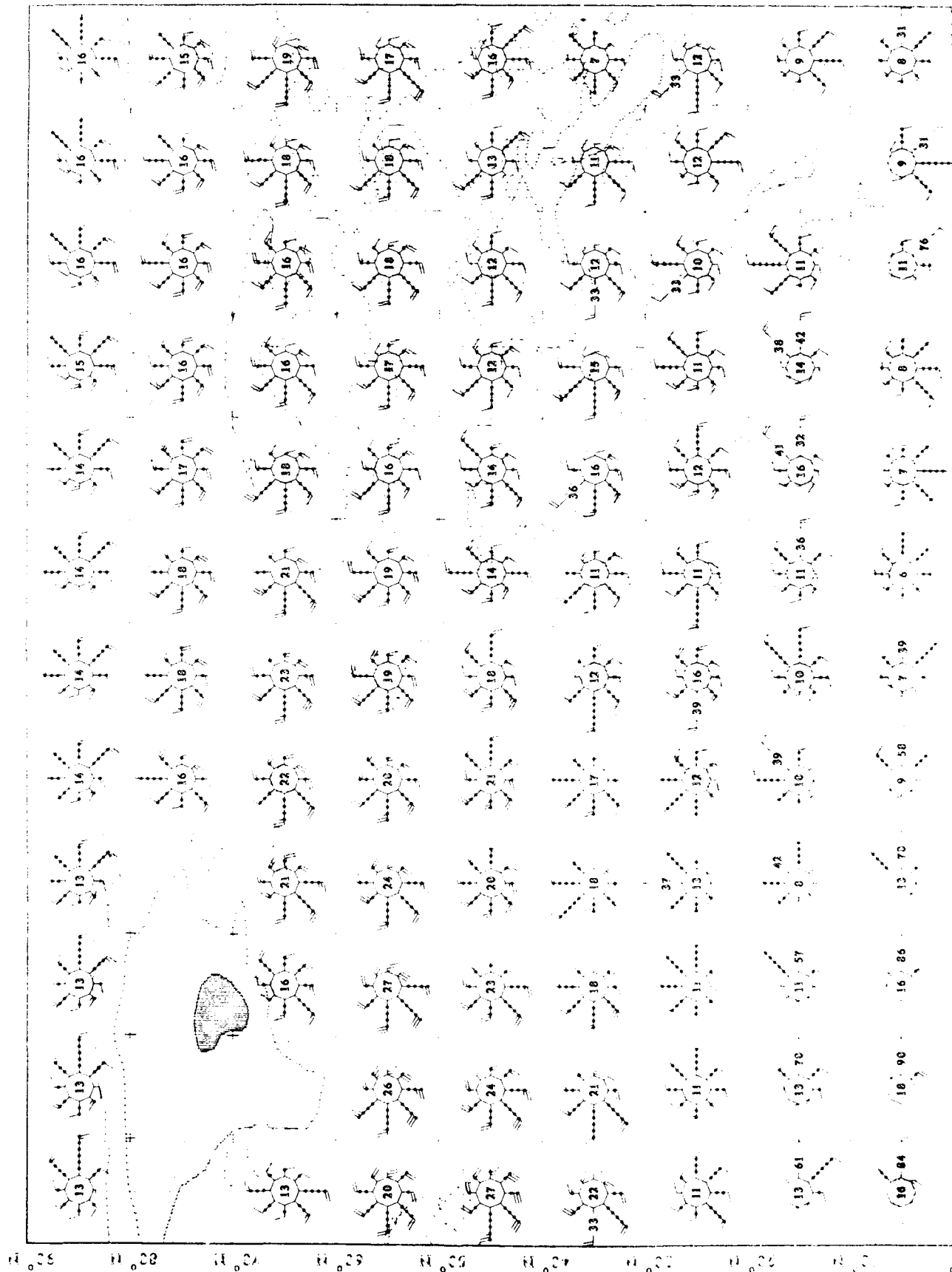
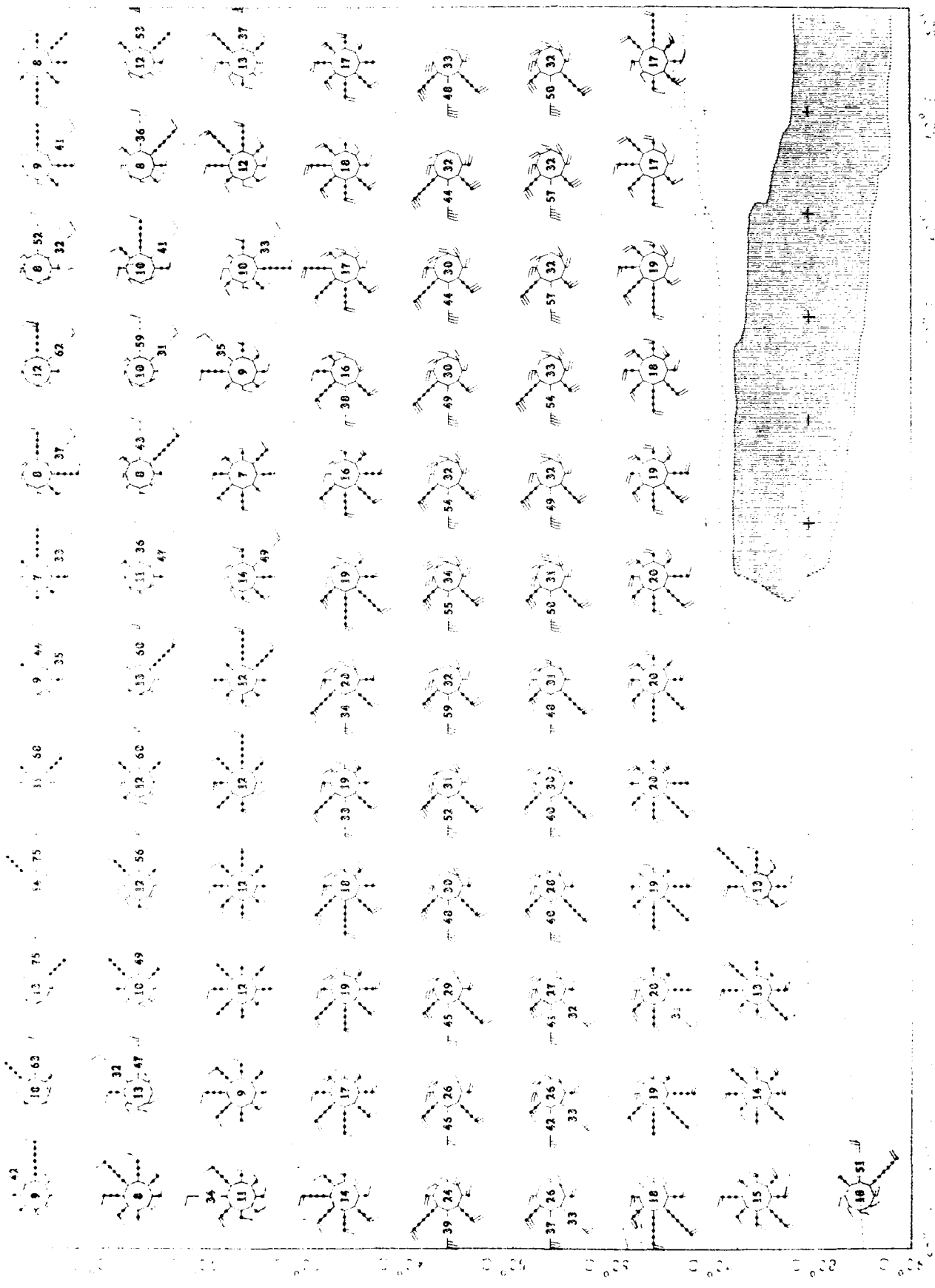


Figure 1: A set of 100 numbered diagrams, likely representing a sequence of points or steps in a geometric pattern.

Figure 1
100 numbered diagrams



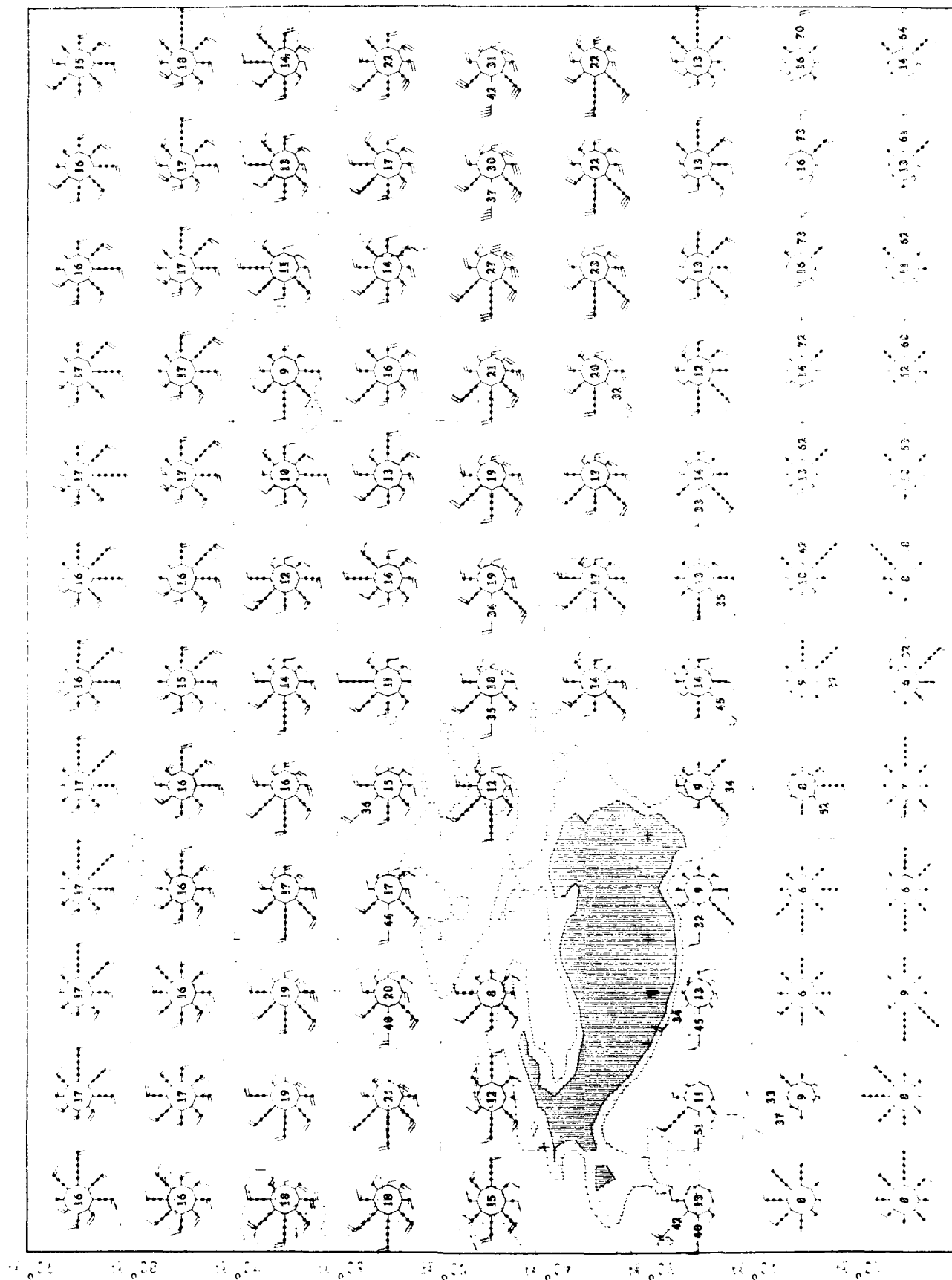




Upper Air Climatology
Southern Hemisphere

1950-1955
1956-1960
1961-1965

1966-1970
1971-1975
1976-1980



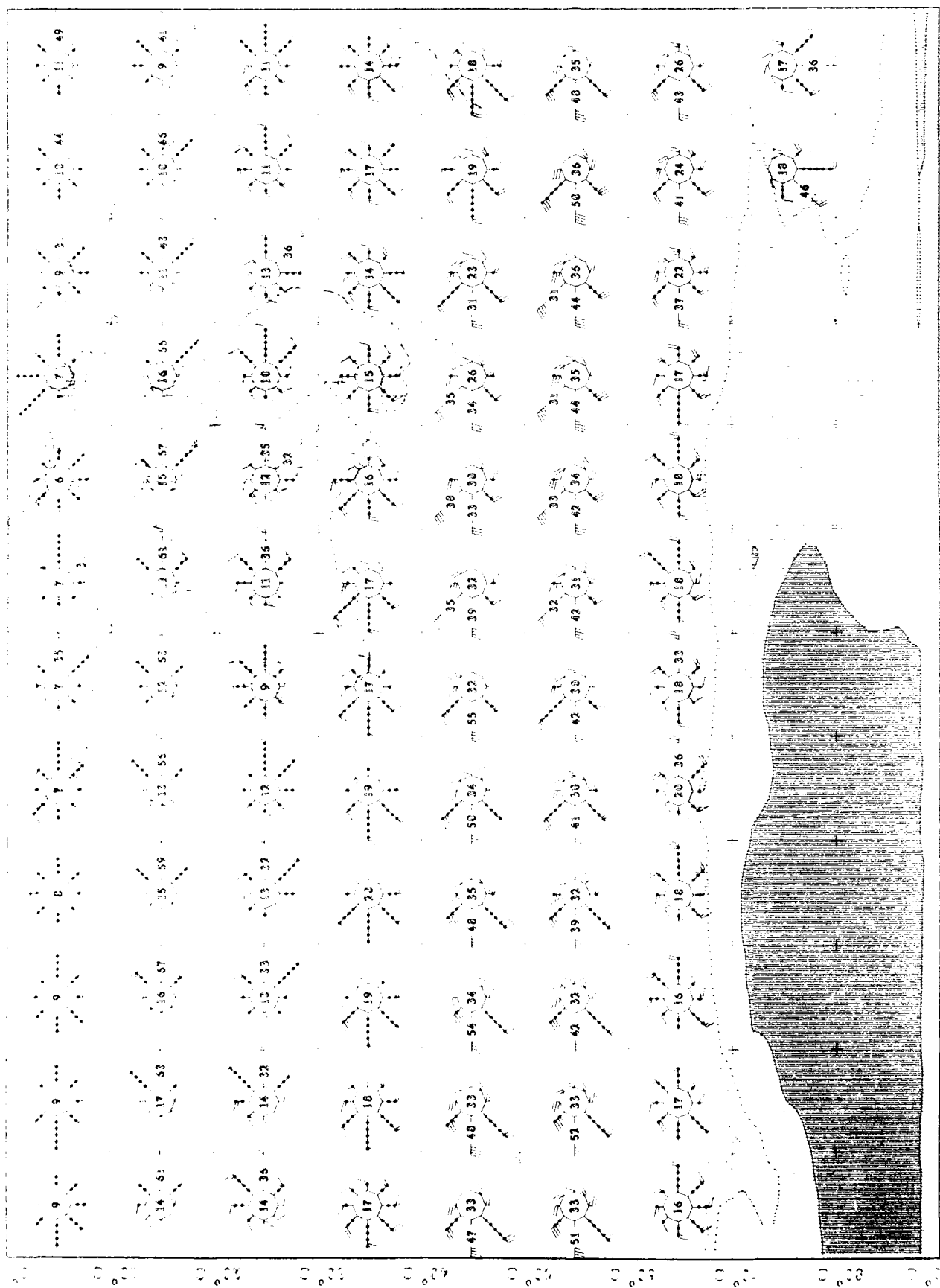
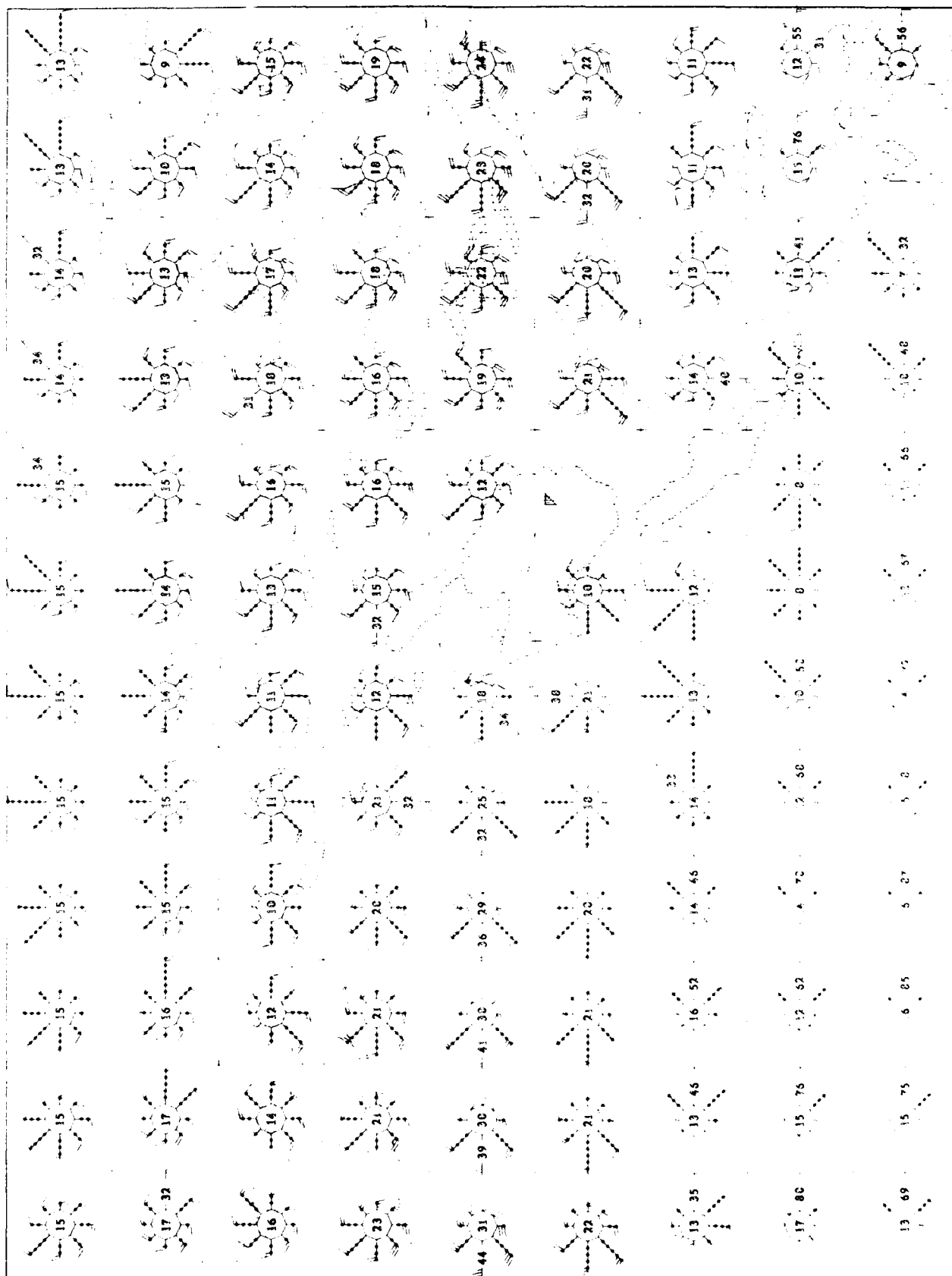
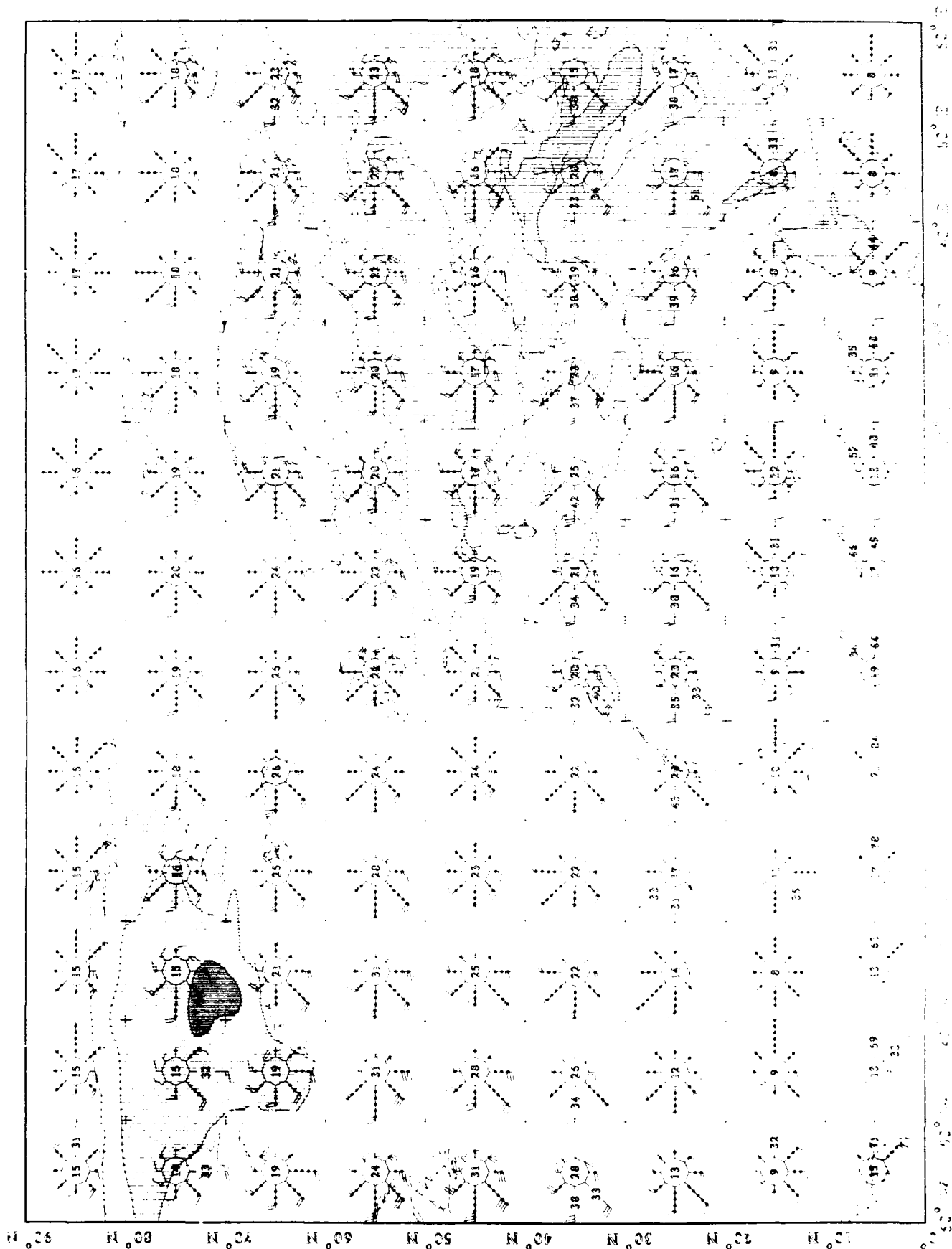


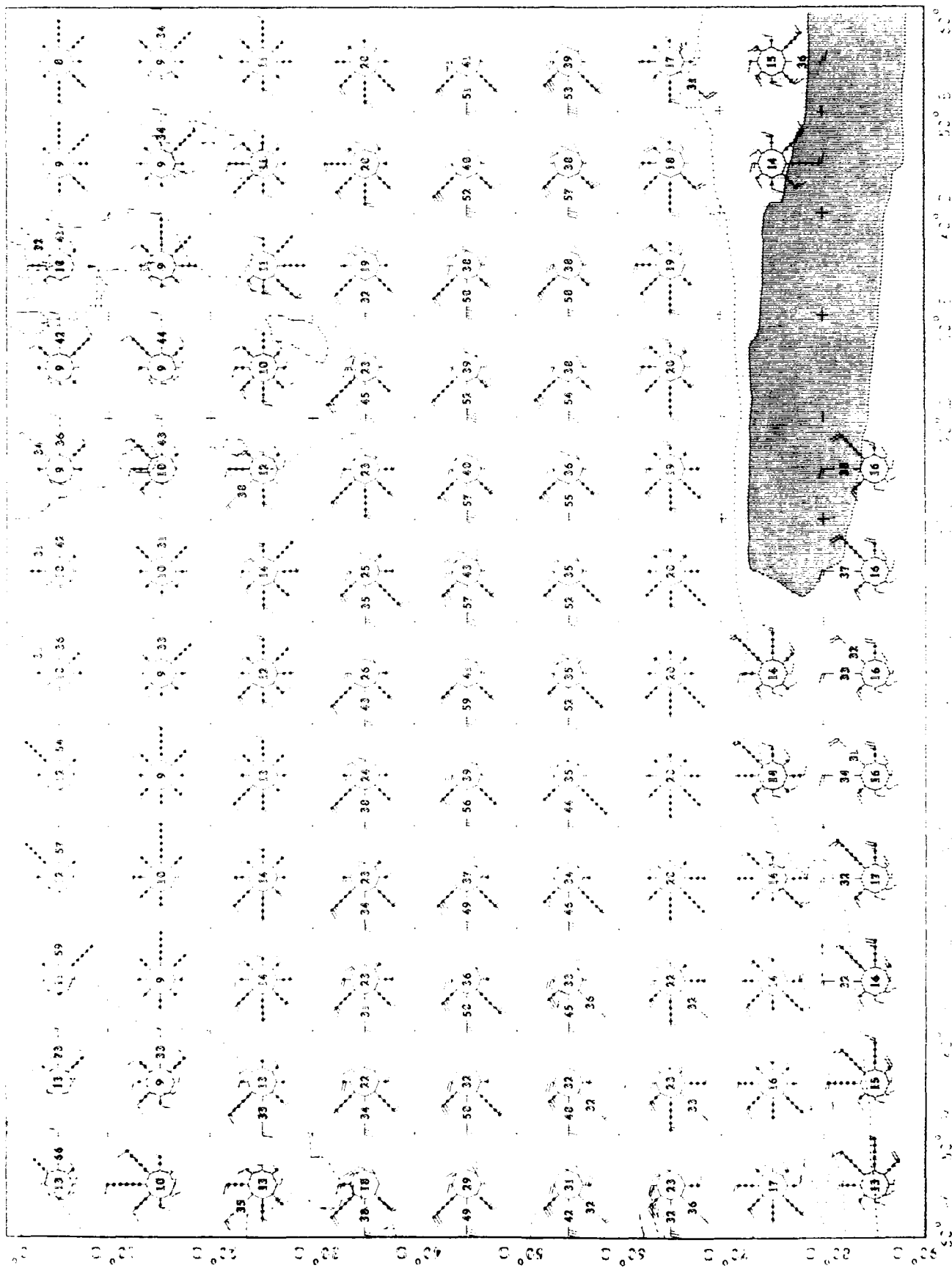
Fig. 2. Map of the...
... ..

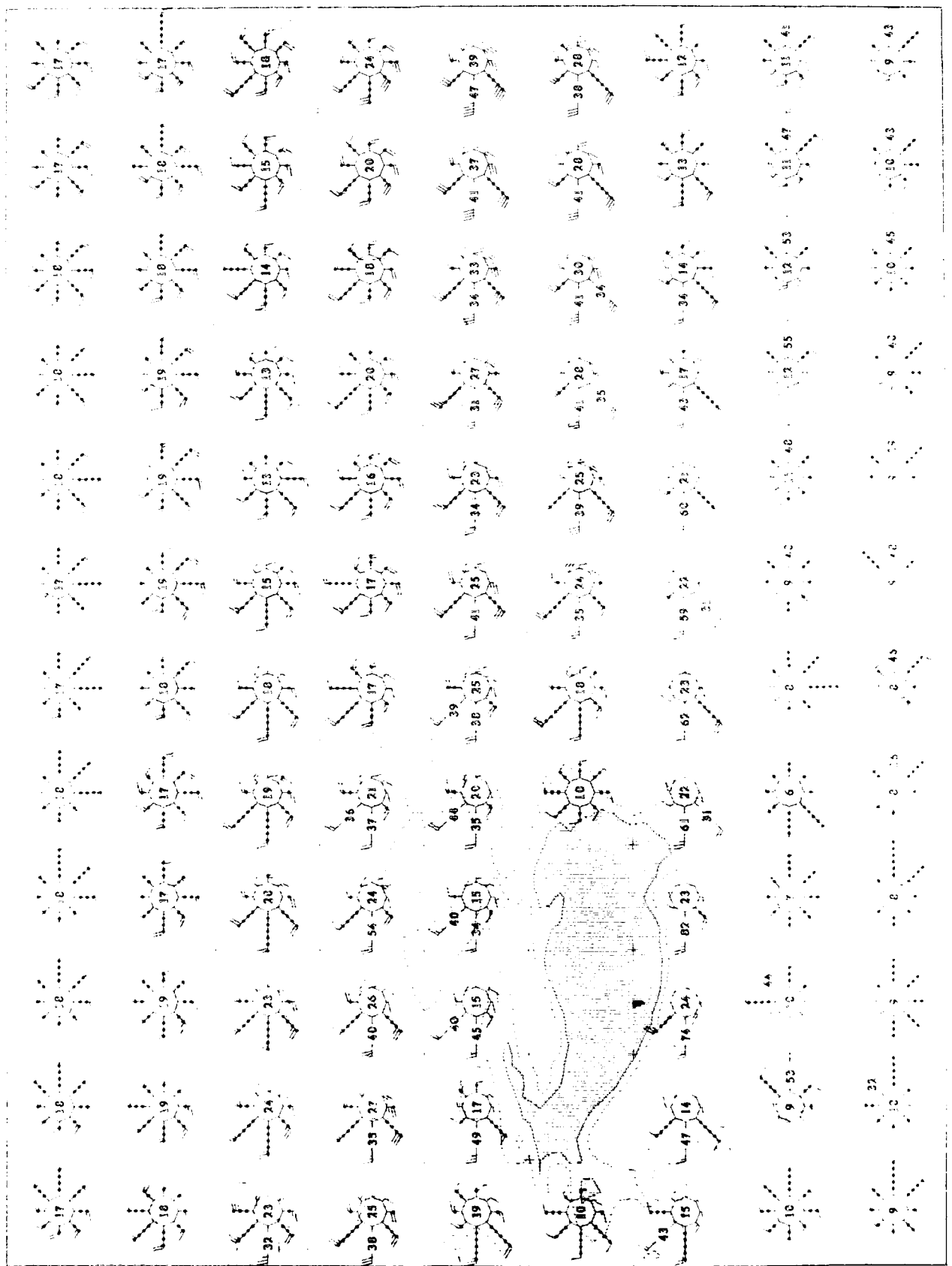
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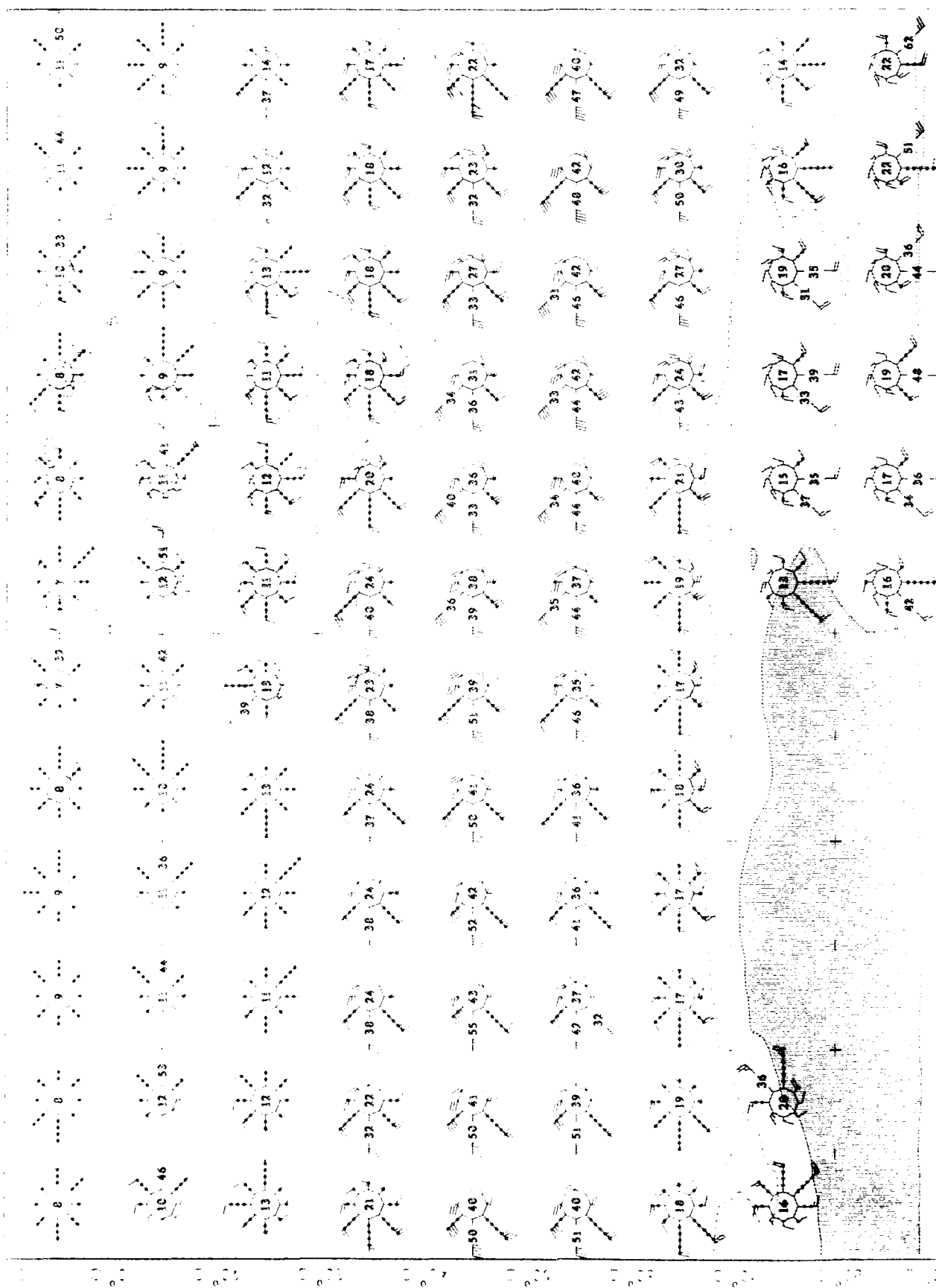
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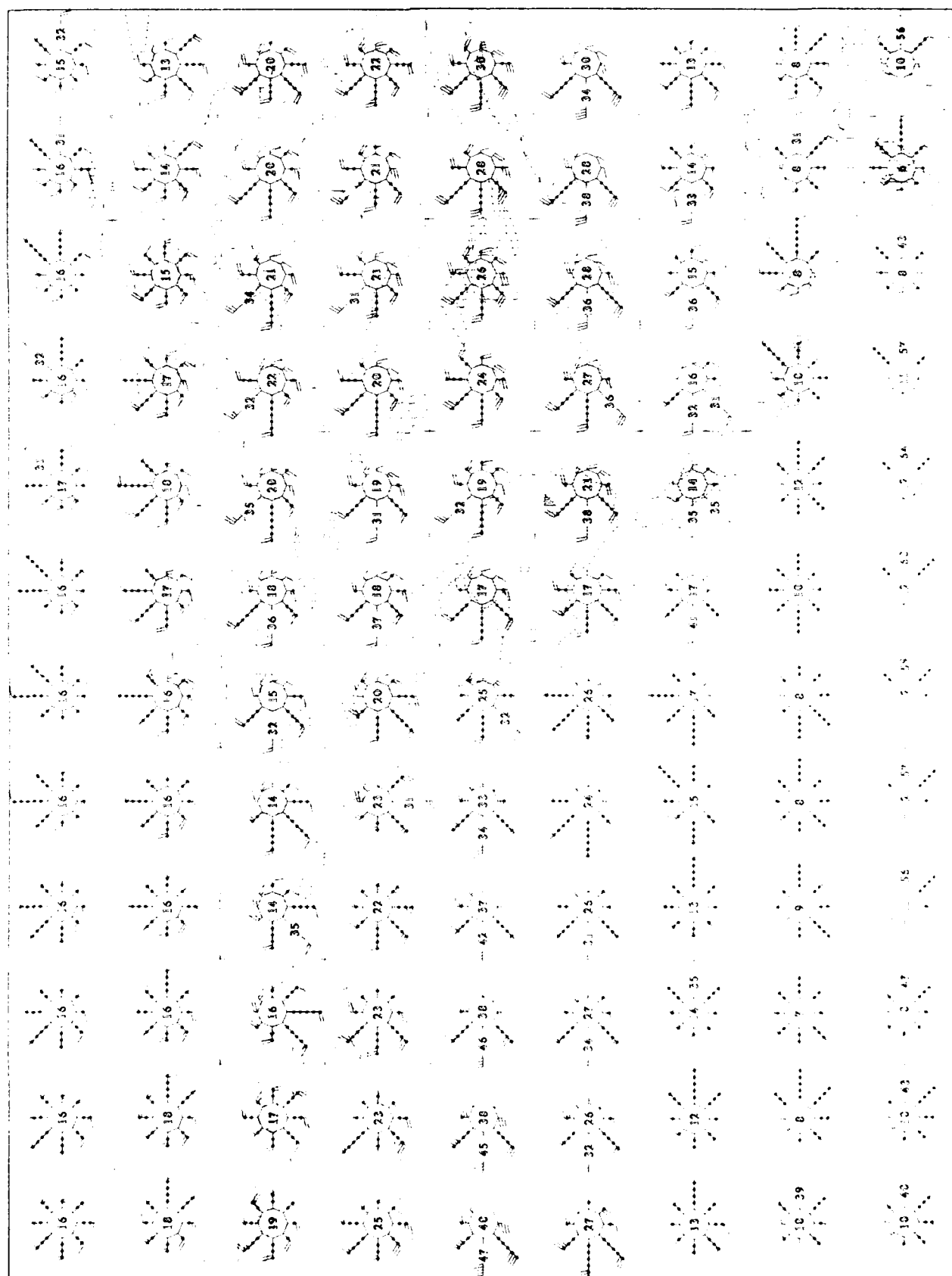


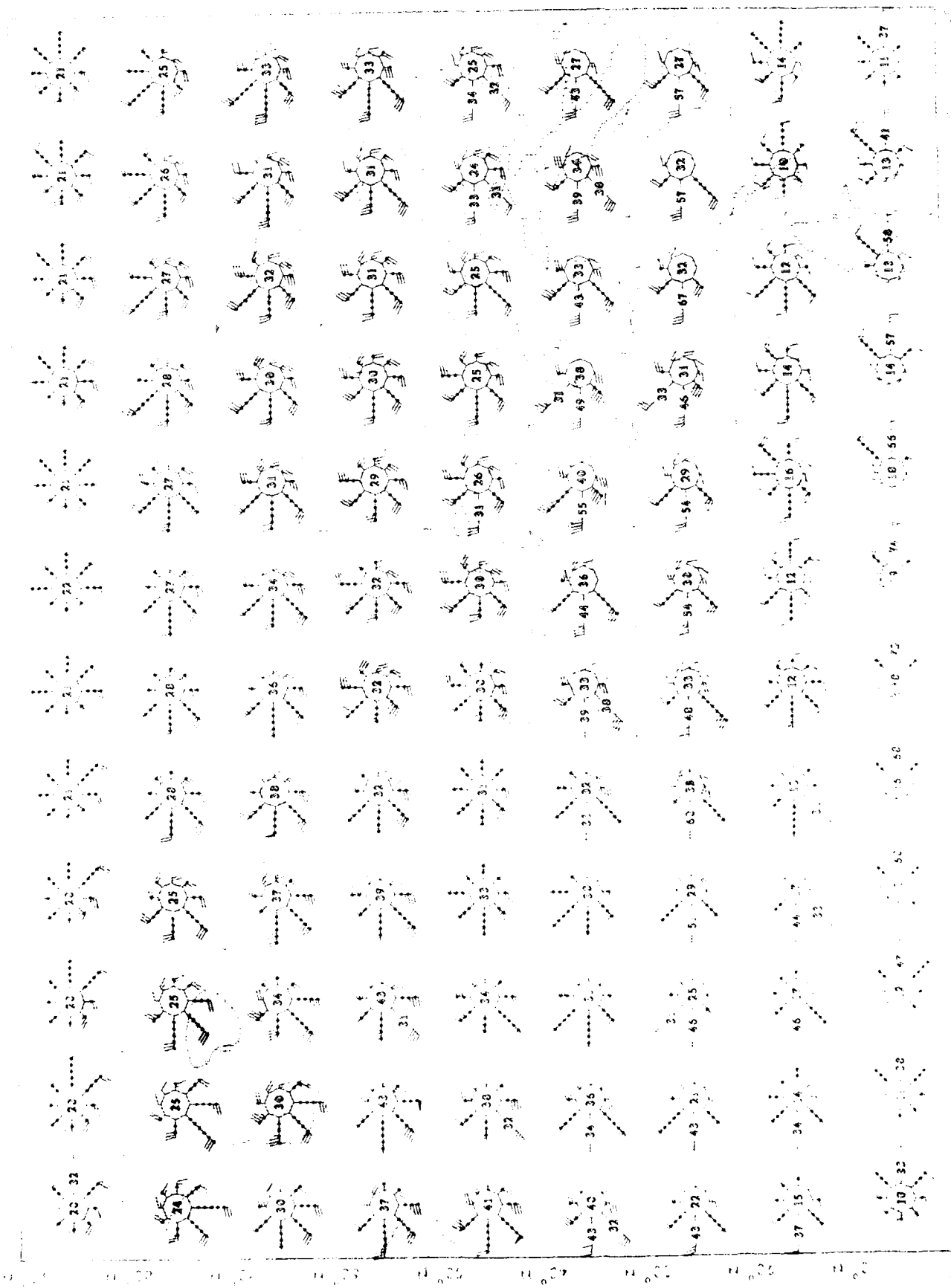


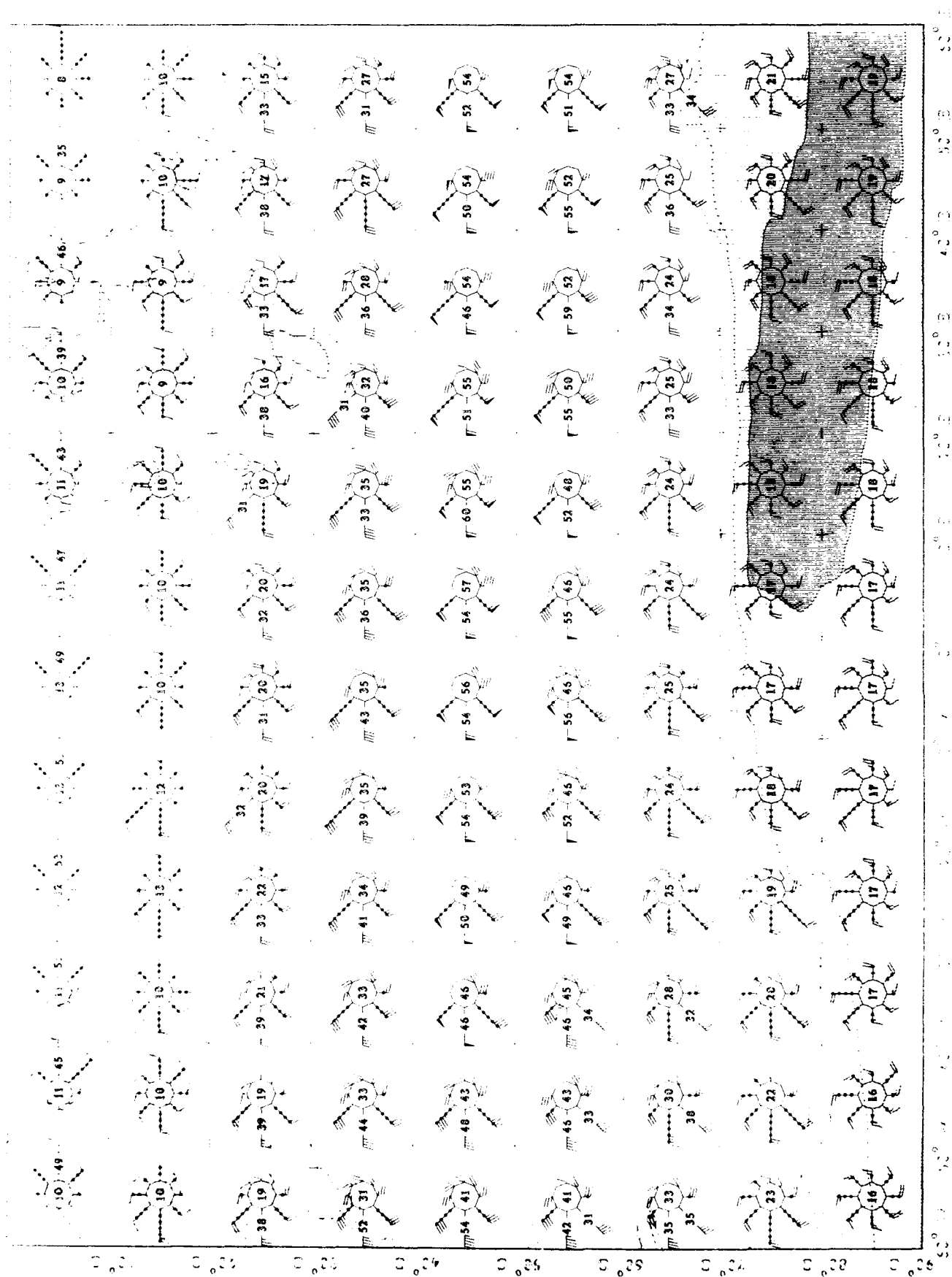








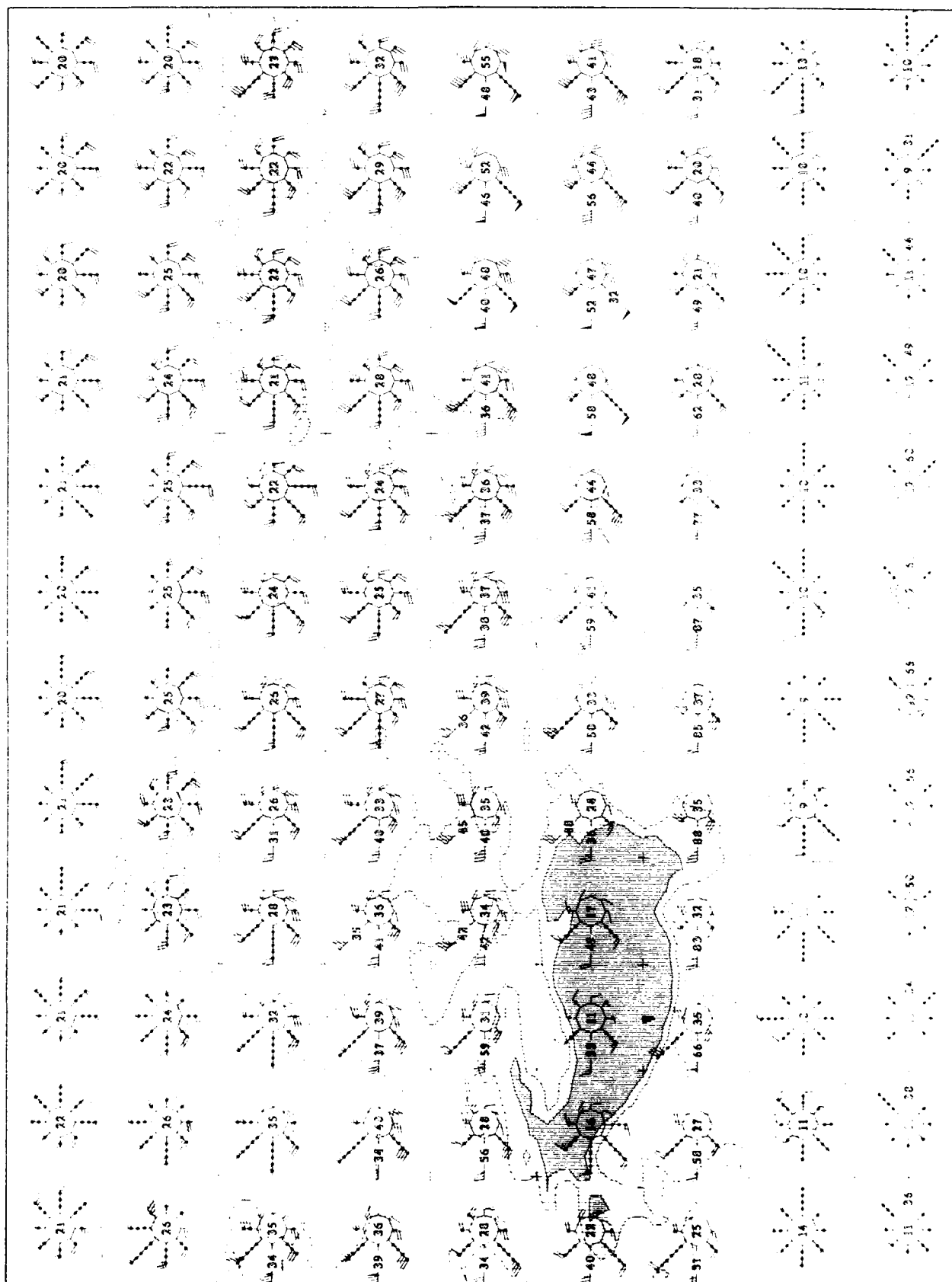


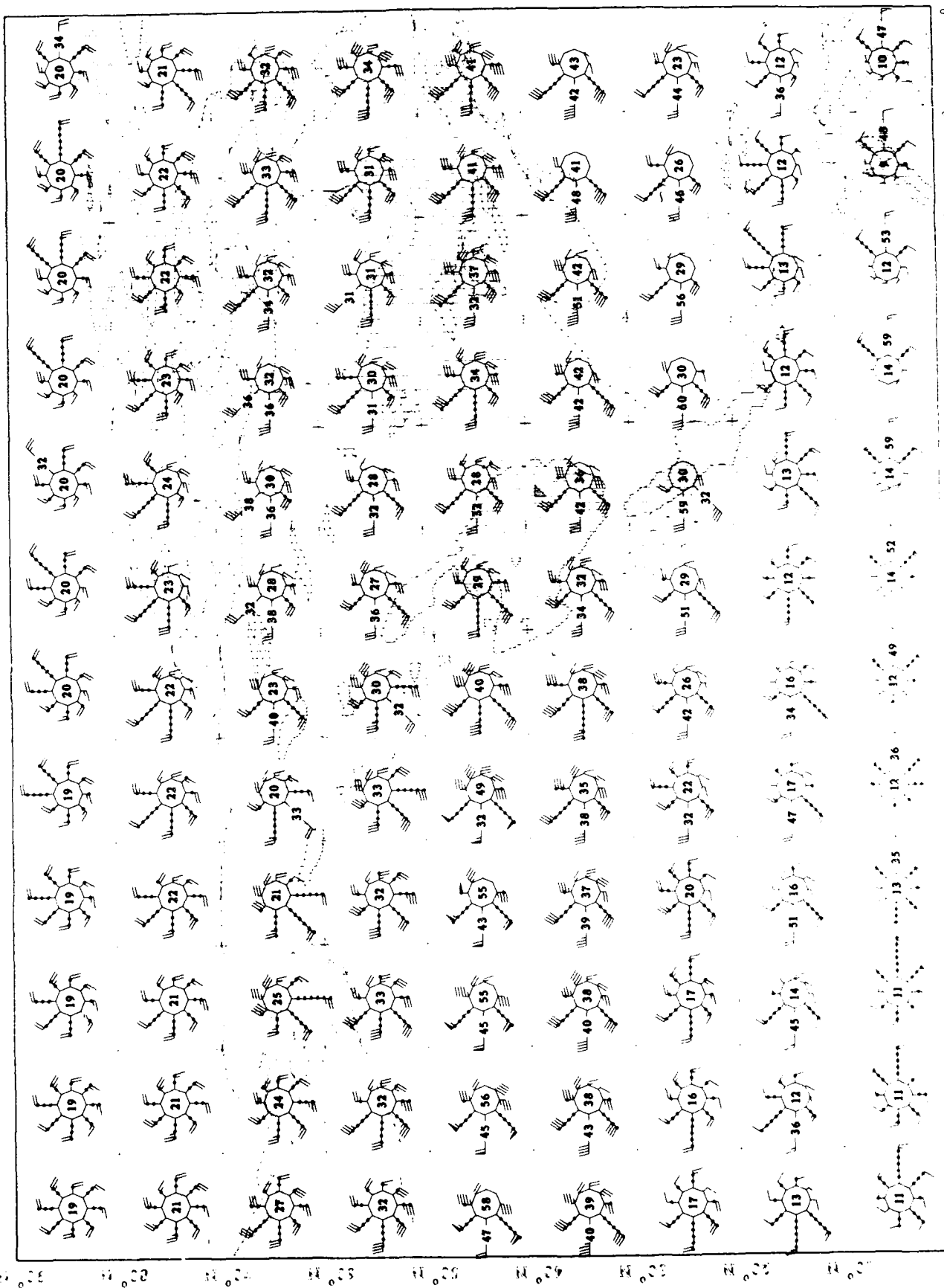


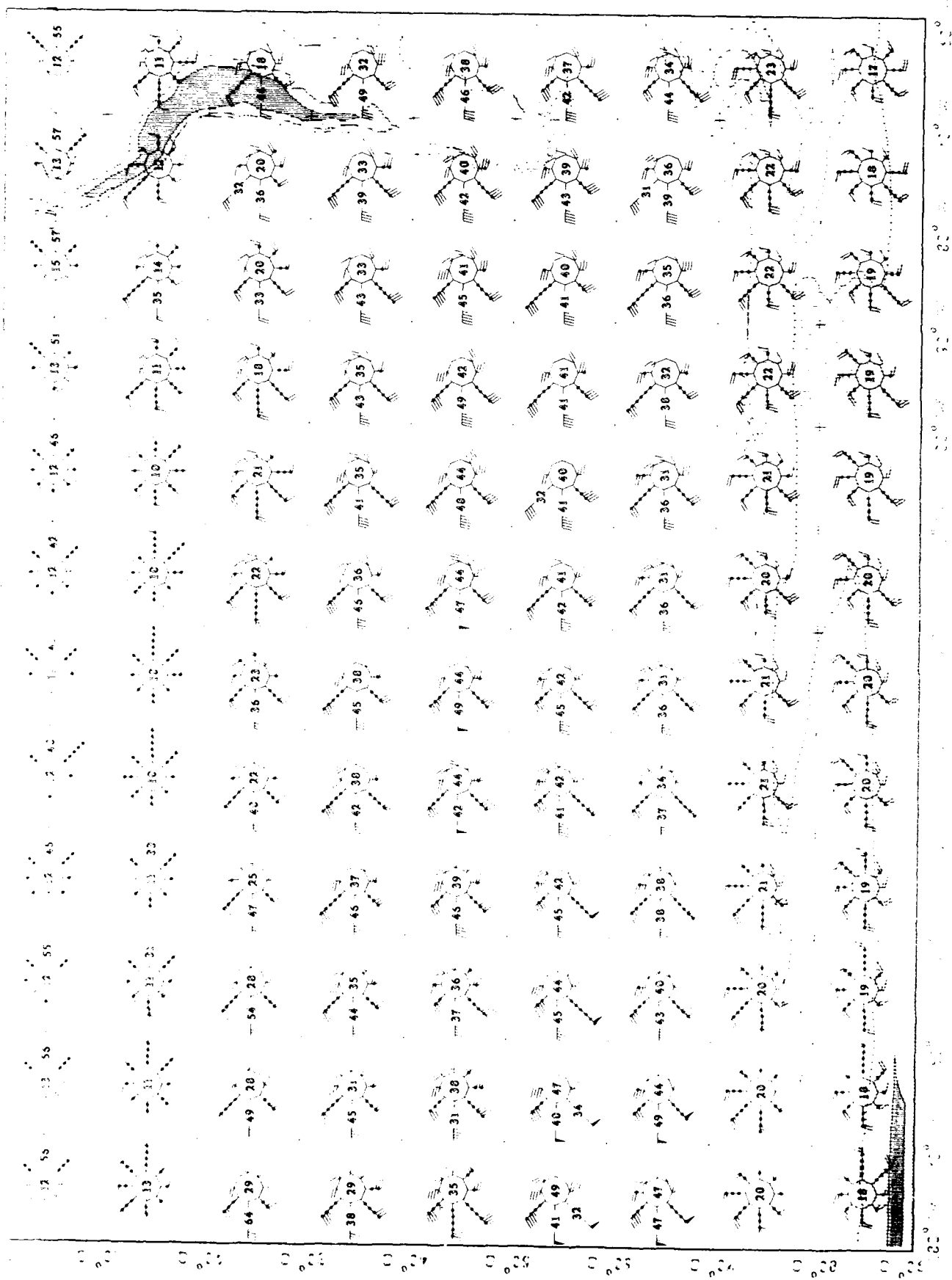
Upper Air Climatology
Southern Hemisphere

500 mb
120°E 120°W

60°S
50°S







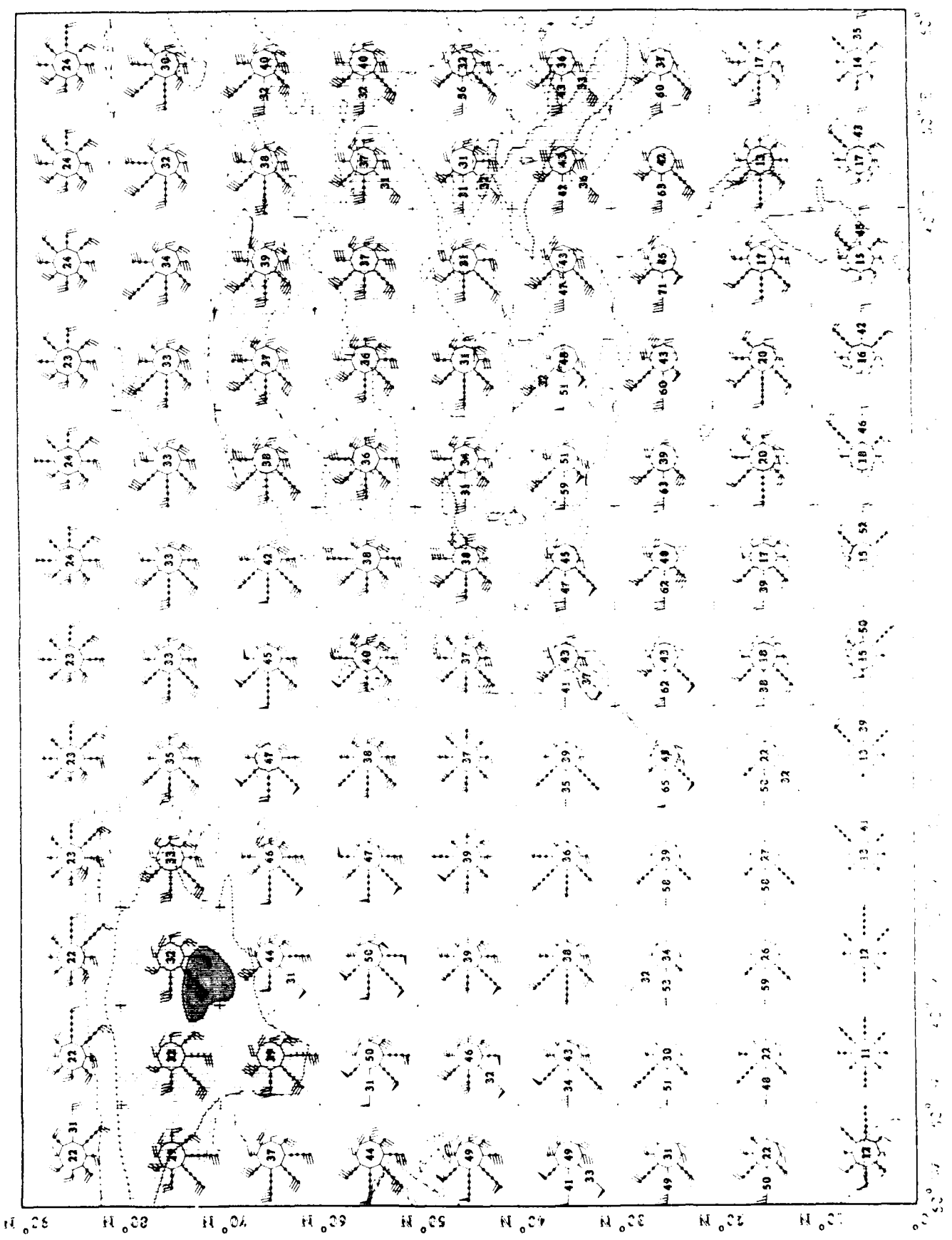
Upper Air Climatology
Southern Hemisphere

1950-1955
1956-1960

1000000
 1000000
 1000000

1000000
 1000000
 1000000

1000000
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 1000000



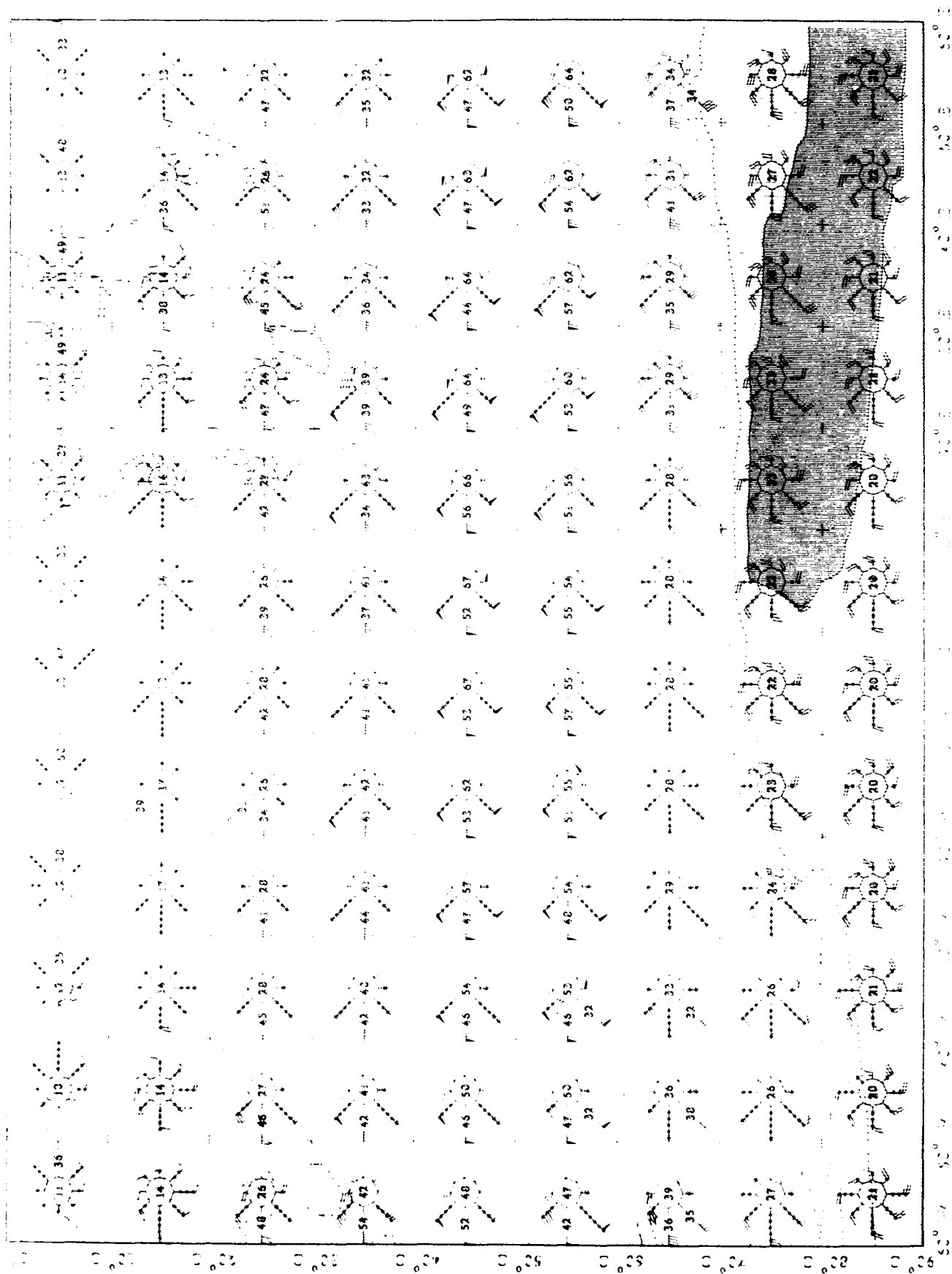
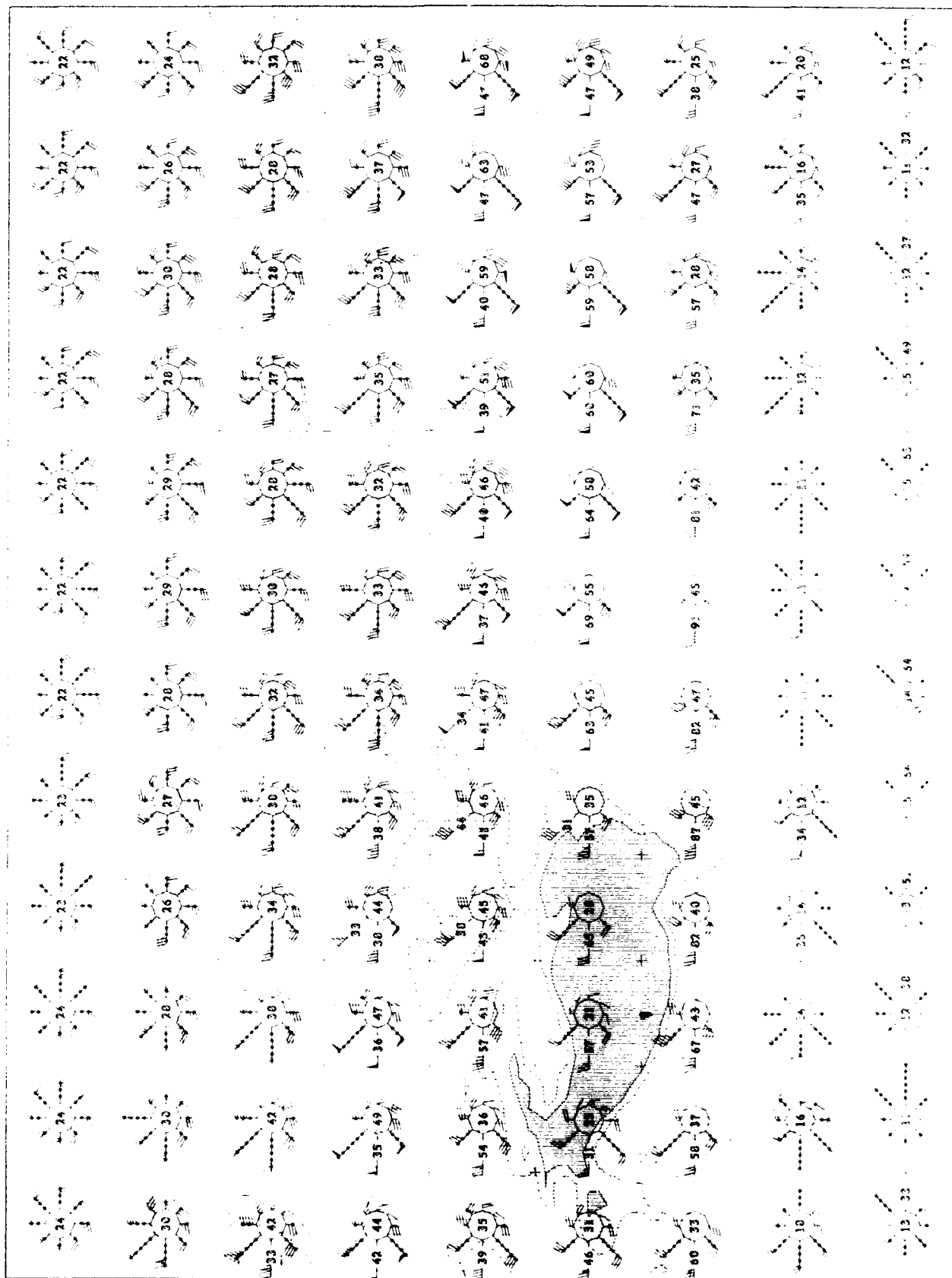
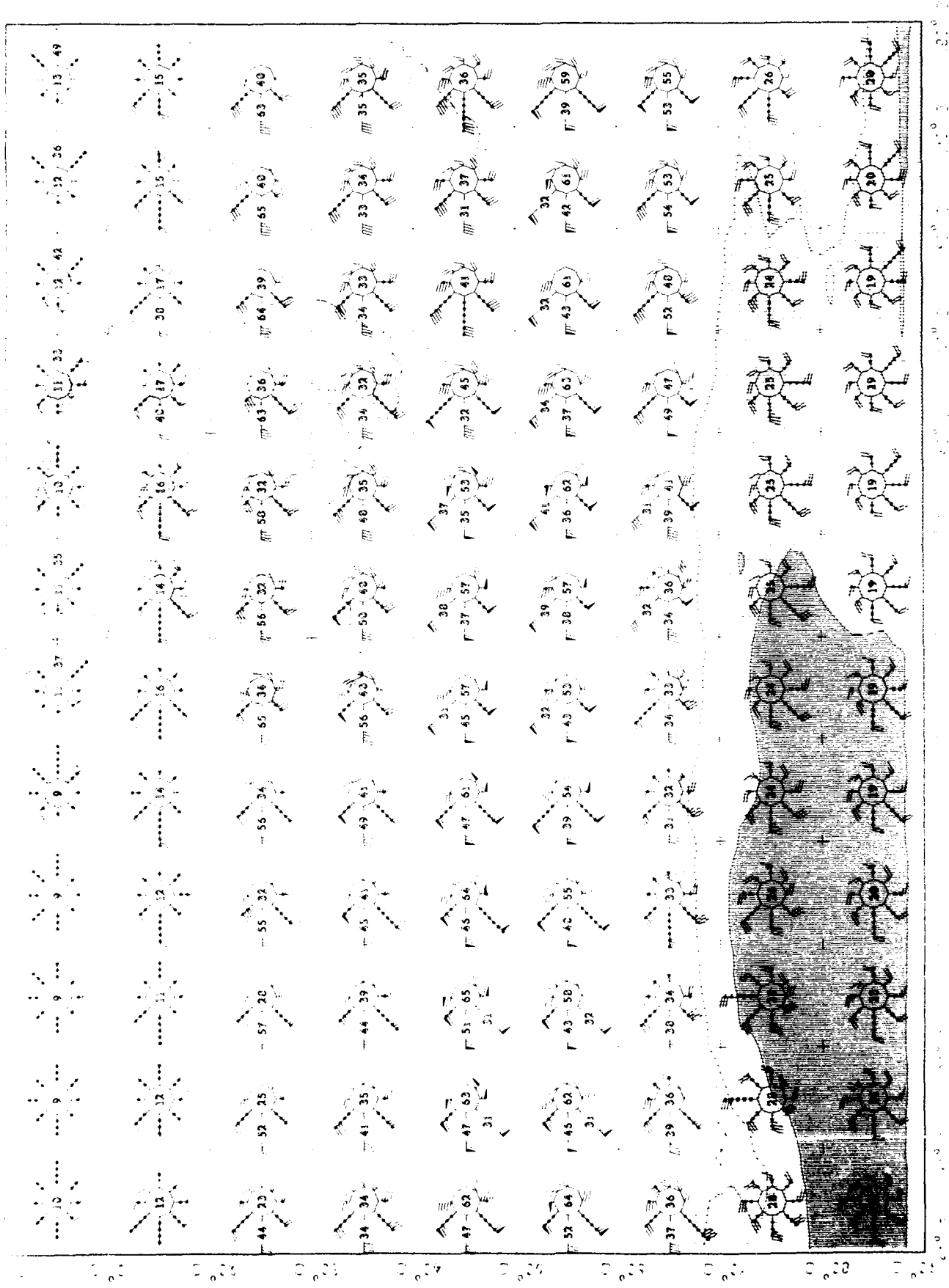


Figure 1. Map of the Pacific Ocean region showing the location of the sampling stations. The shaded area represents the Pacific Islands.

Figure 2. Map of the Pacific Ocean region showing the location of the sampling stations. The shaded area represents the Pacific Islands.



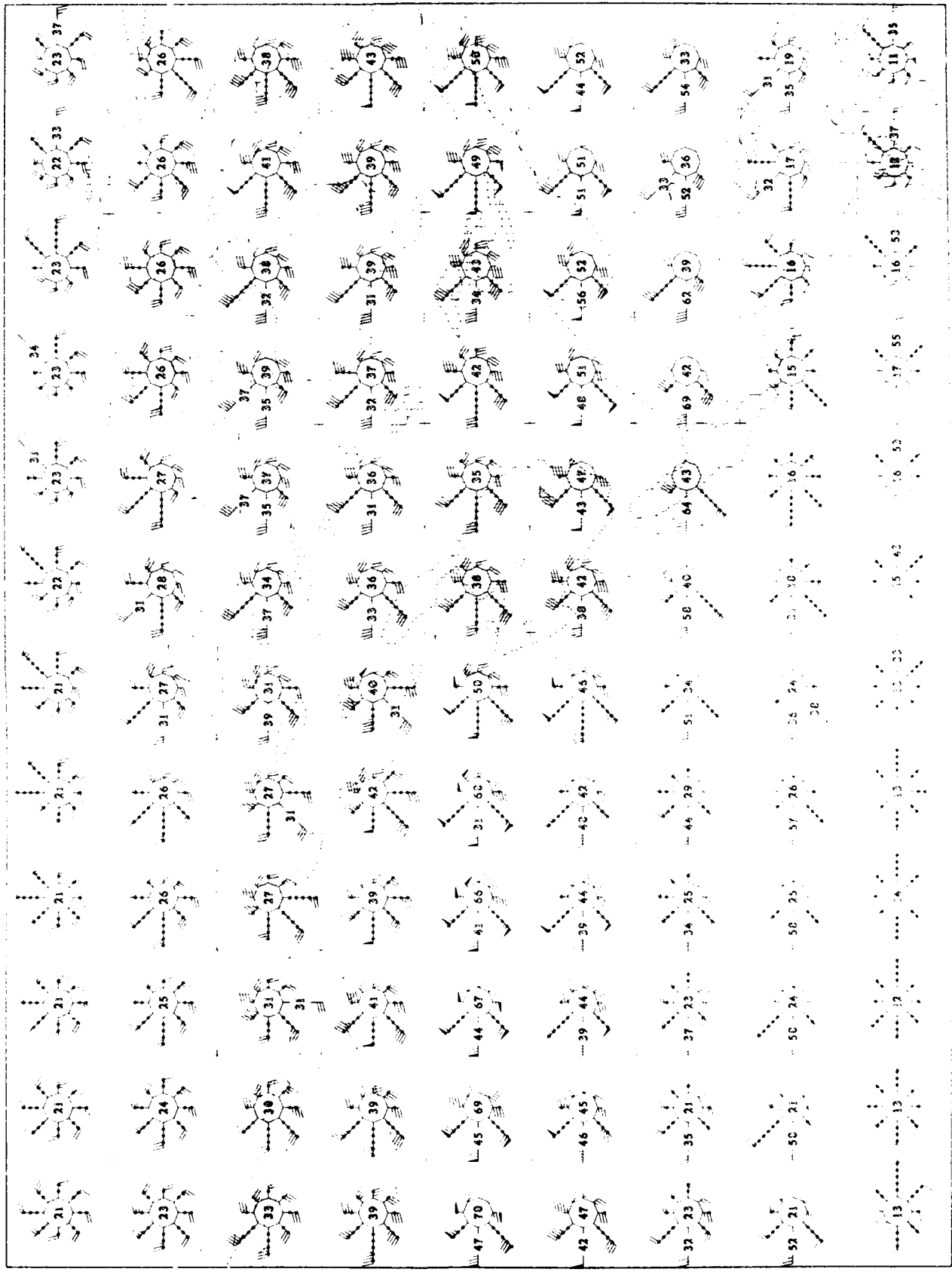


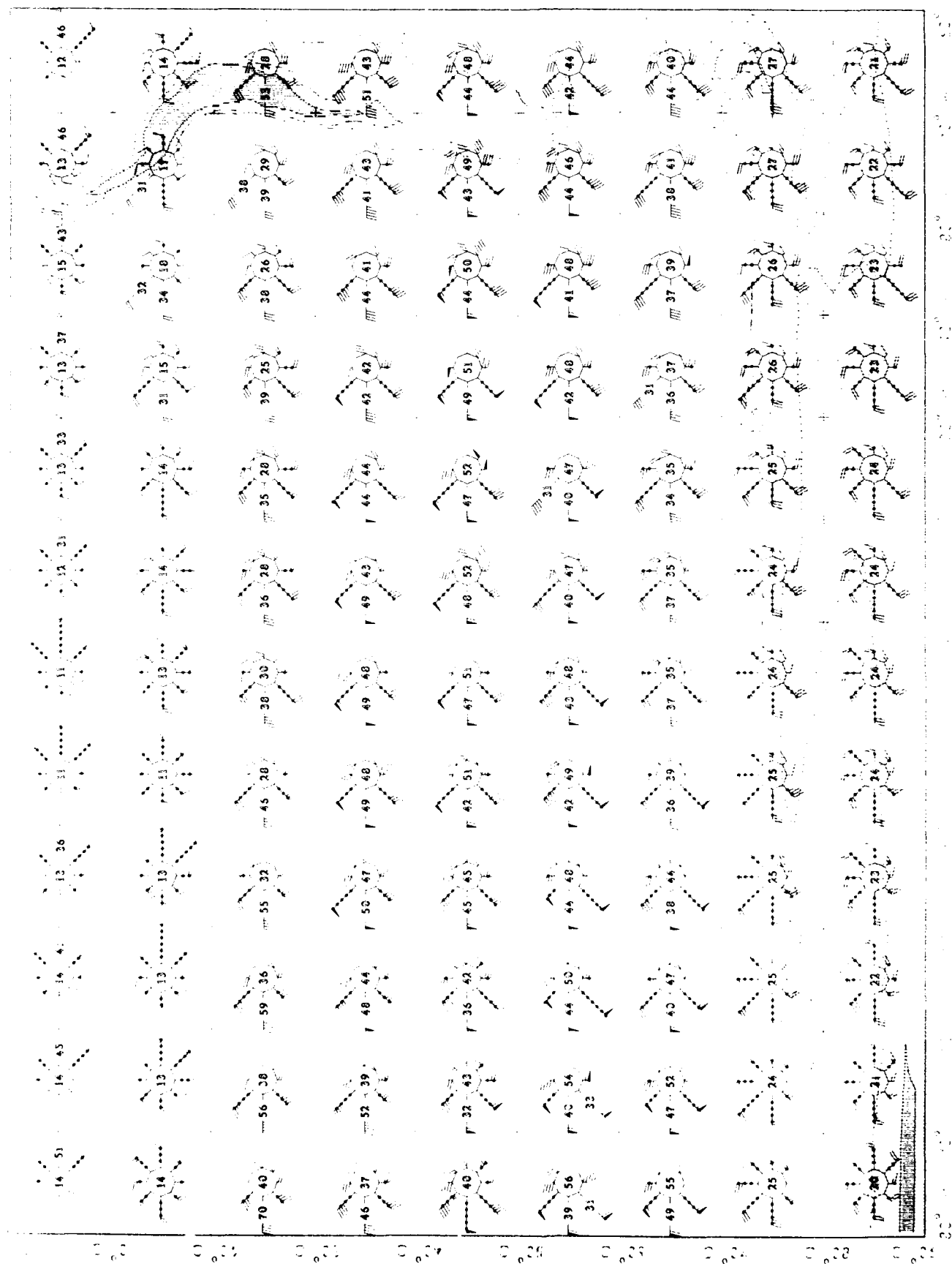
Upper and Lower
Central Hemisphere

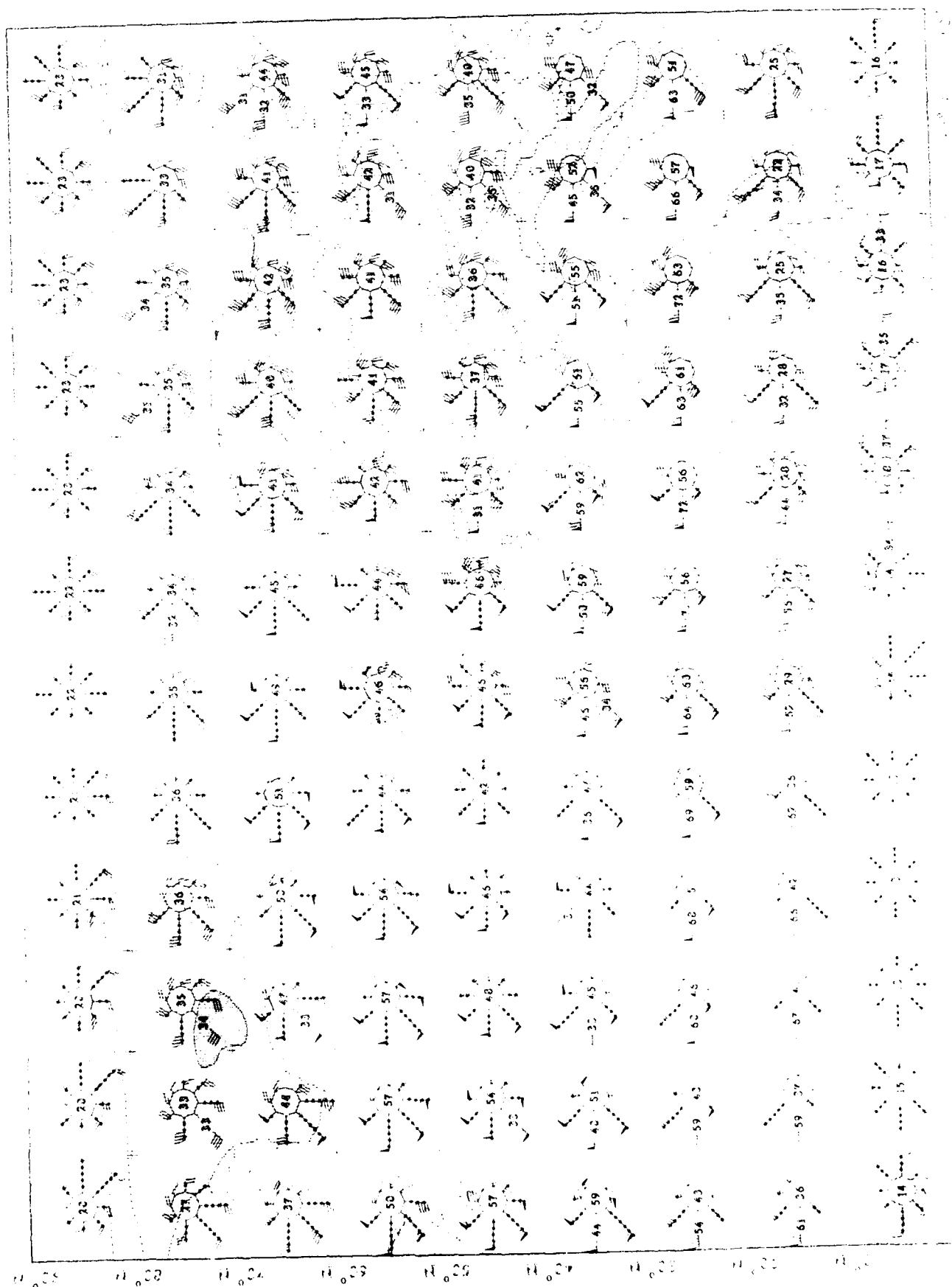
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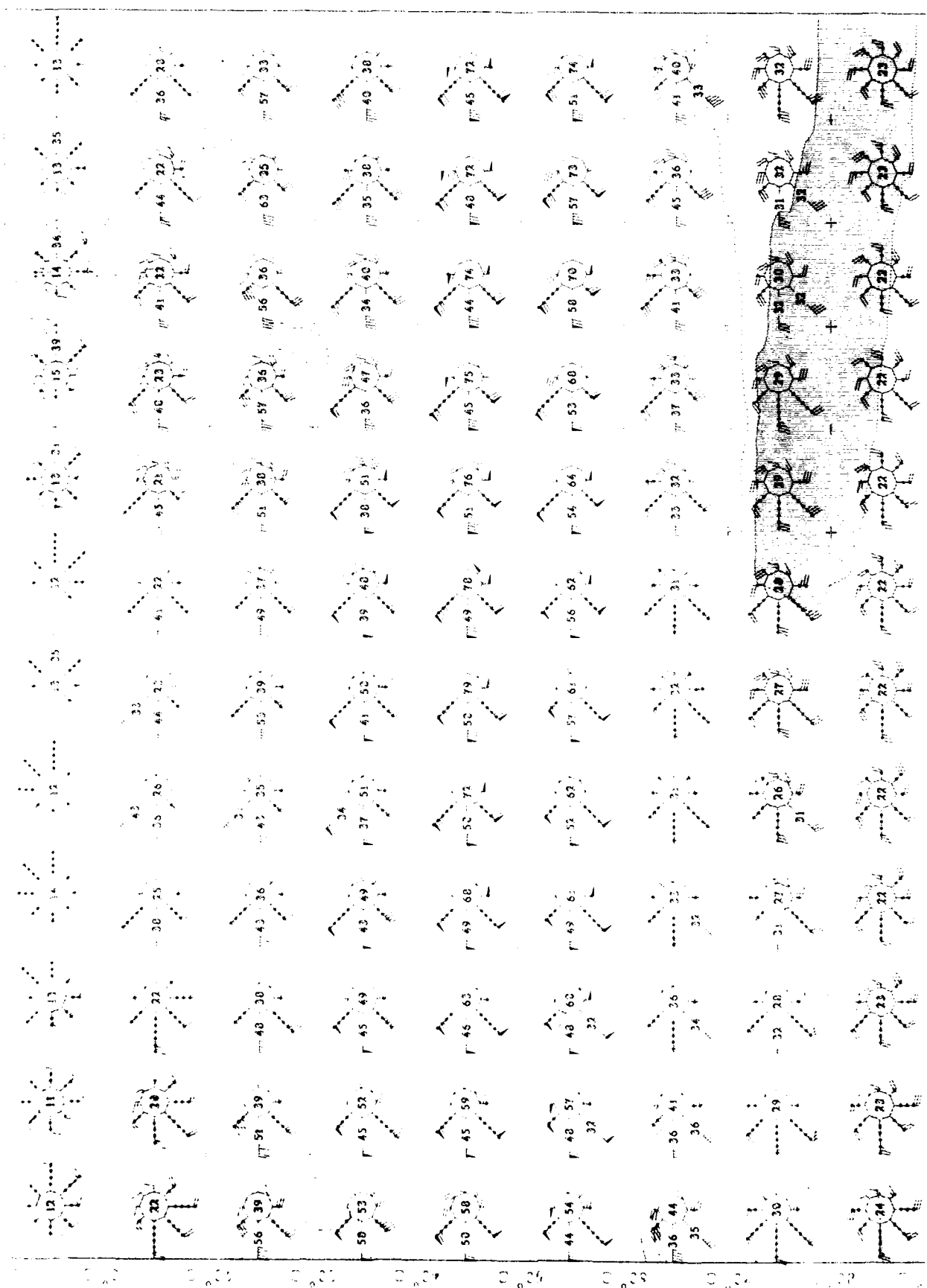
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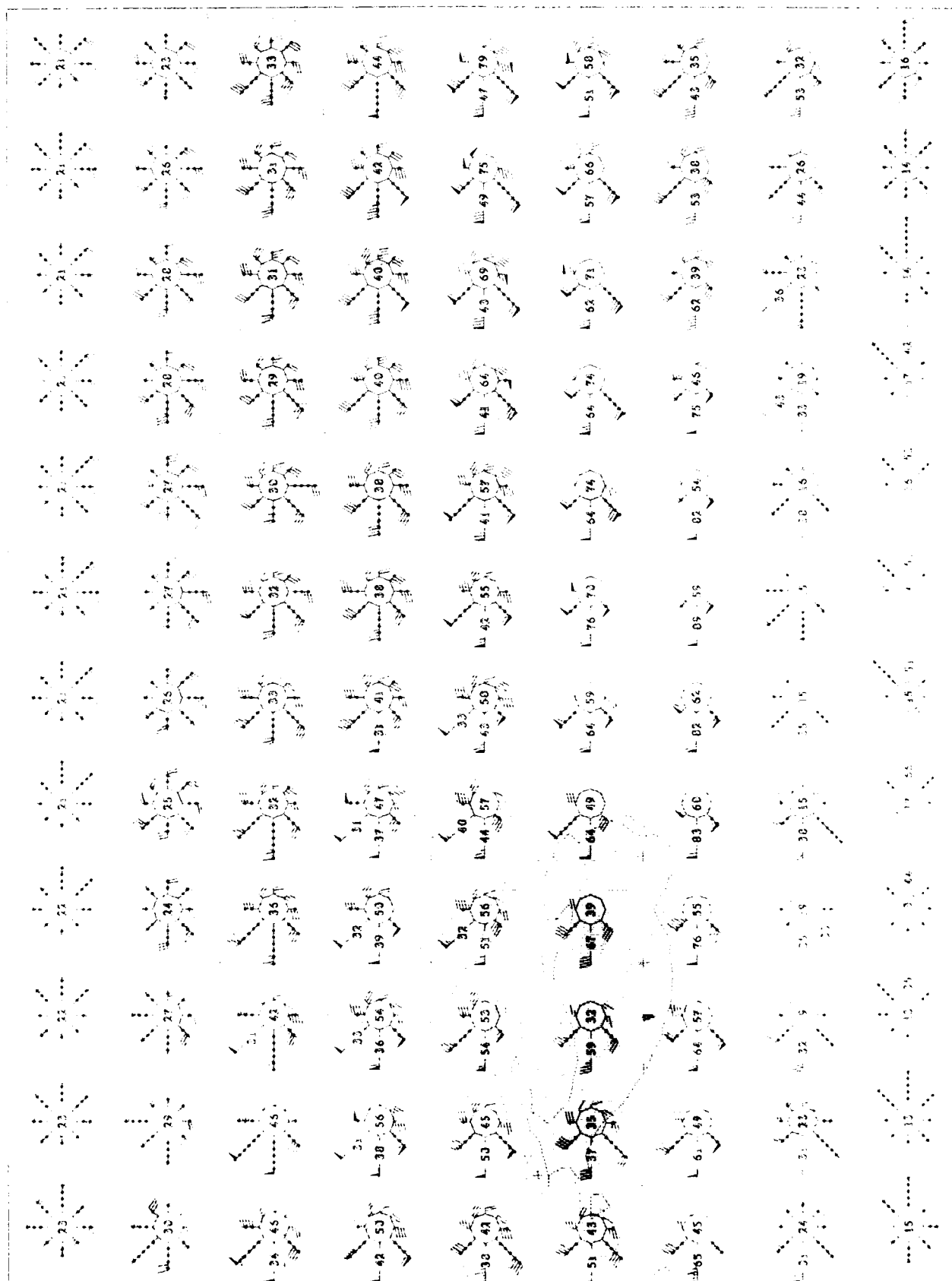
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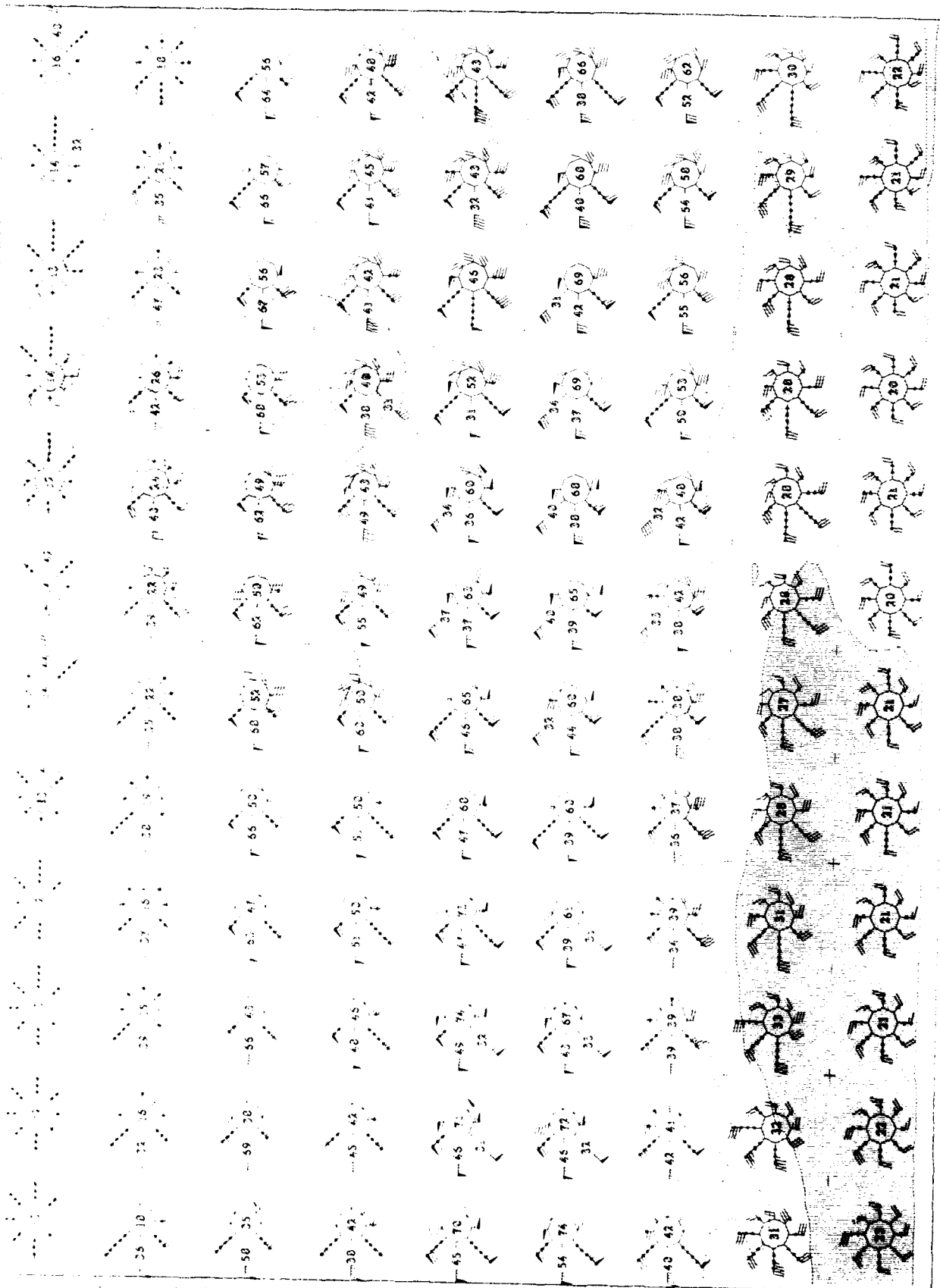
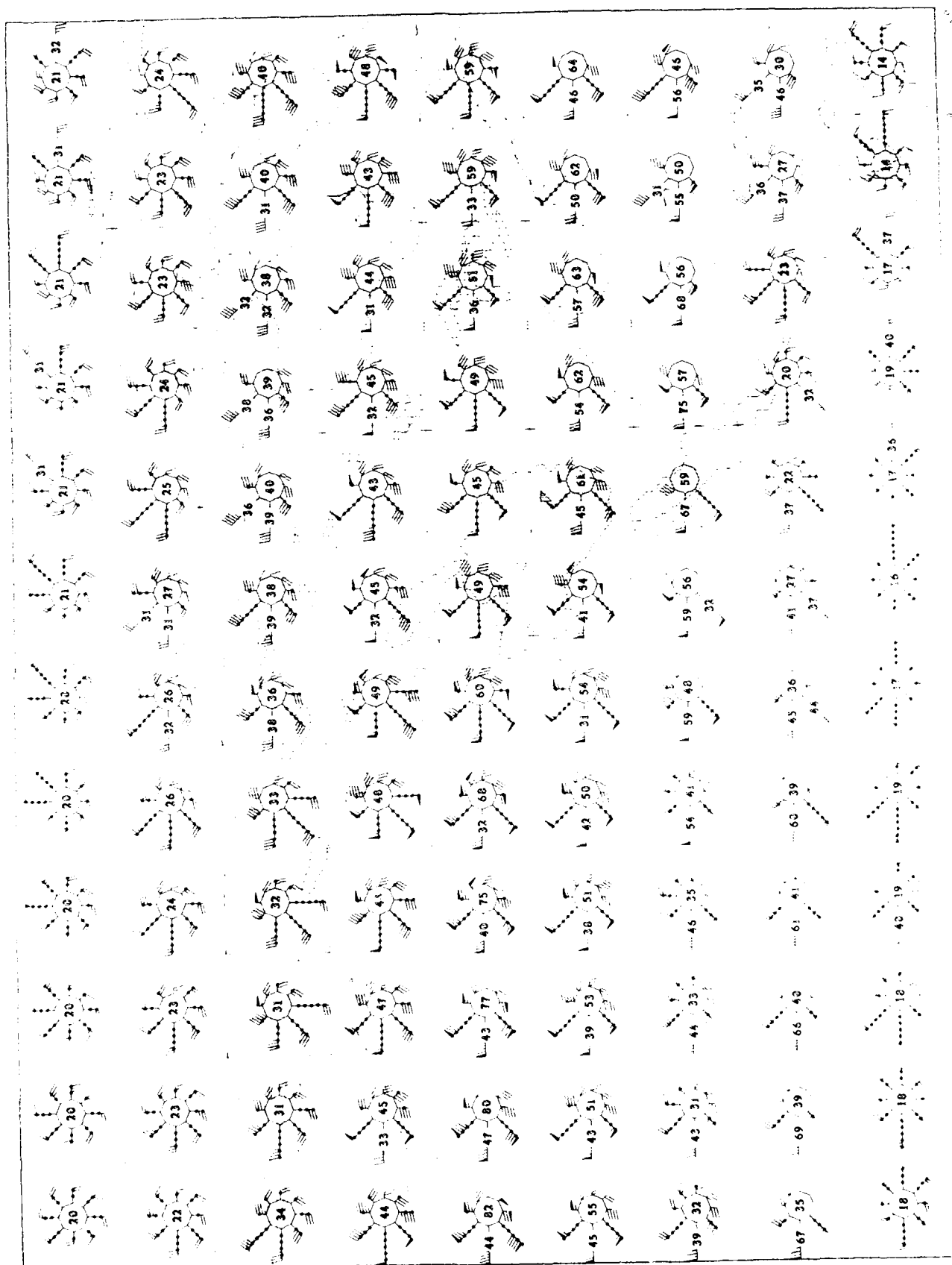
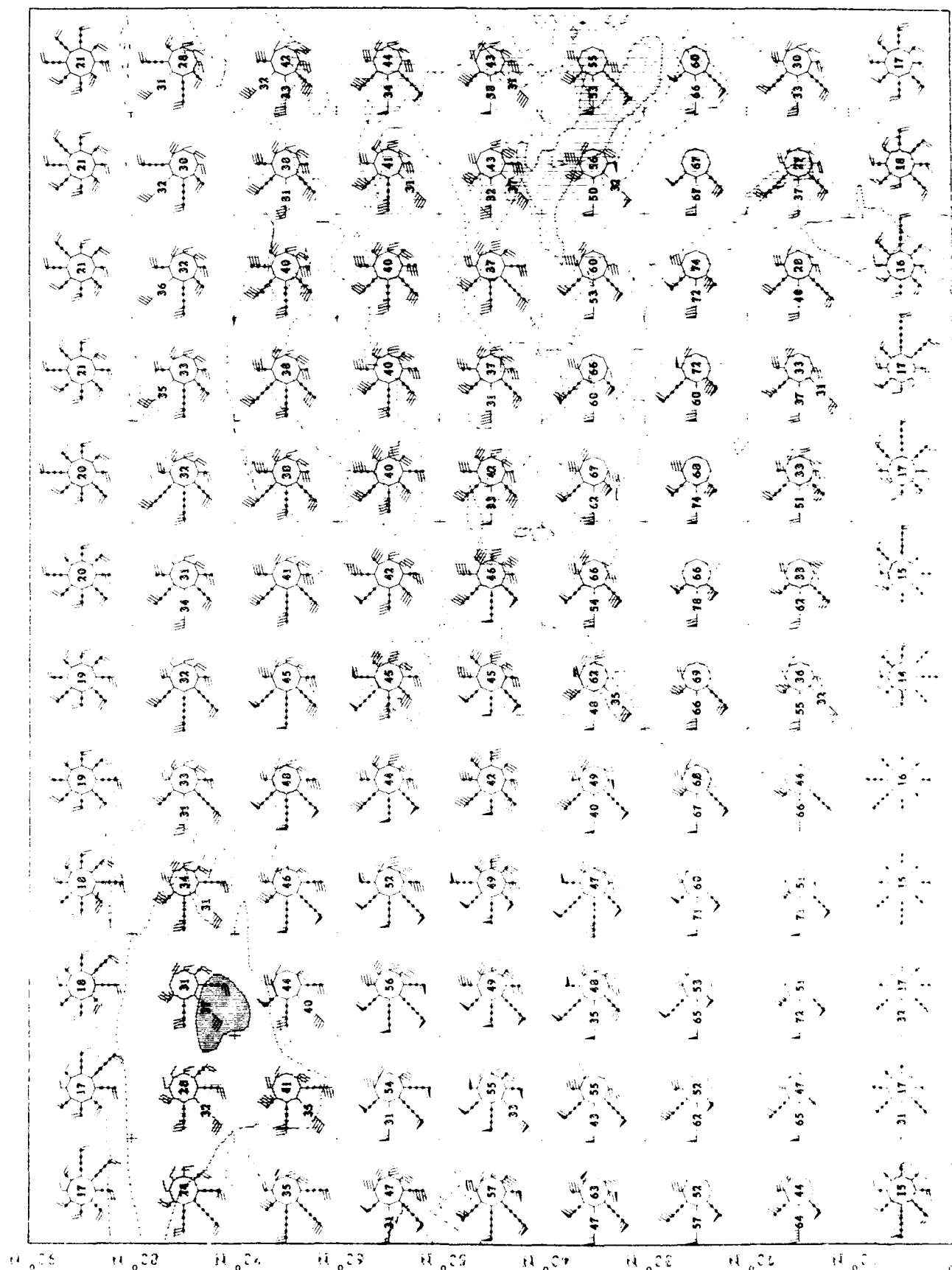
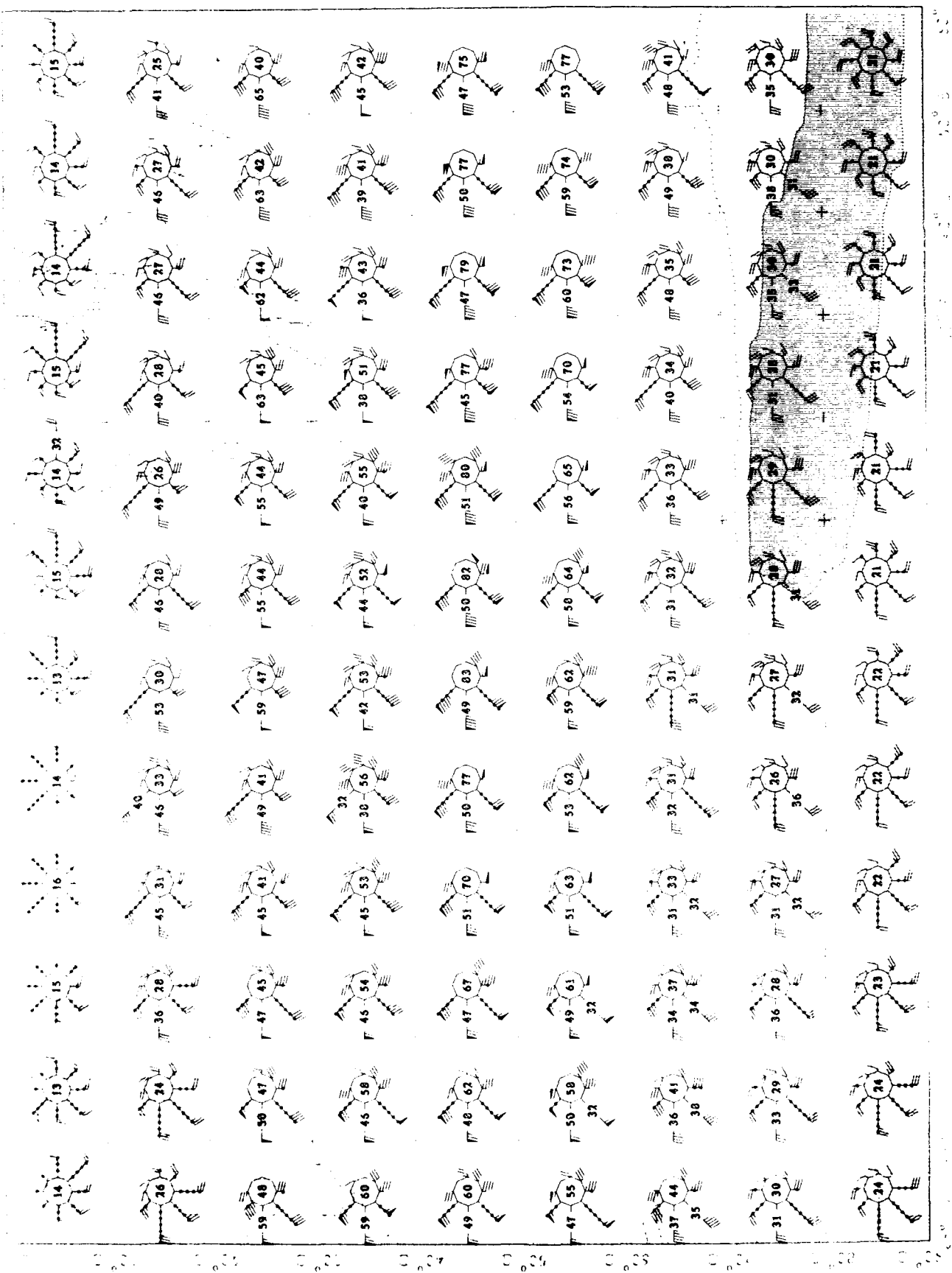


Figure 100: Human Figure

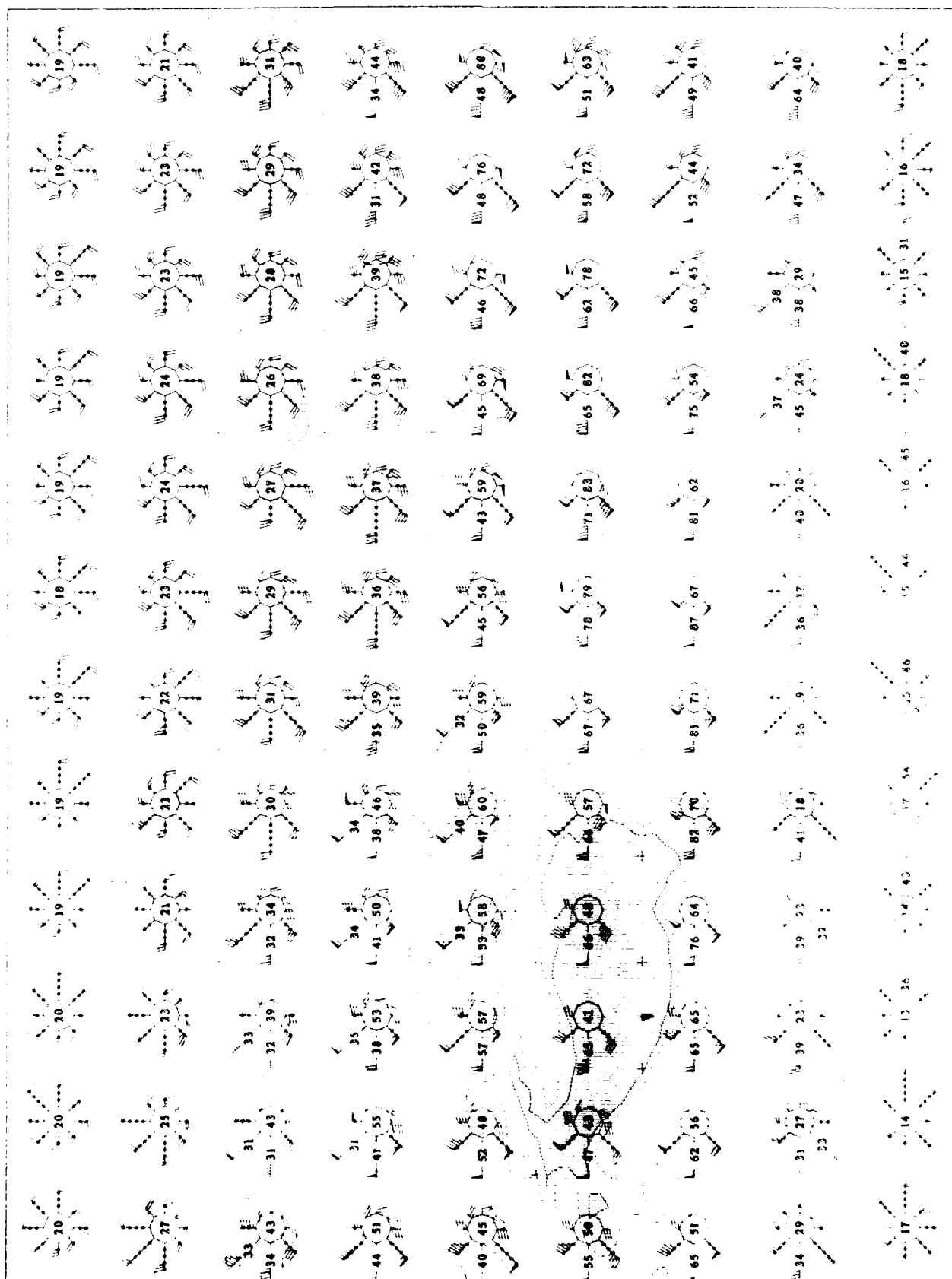


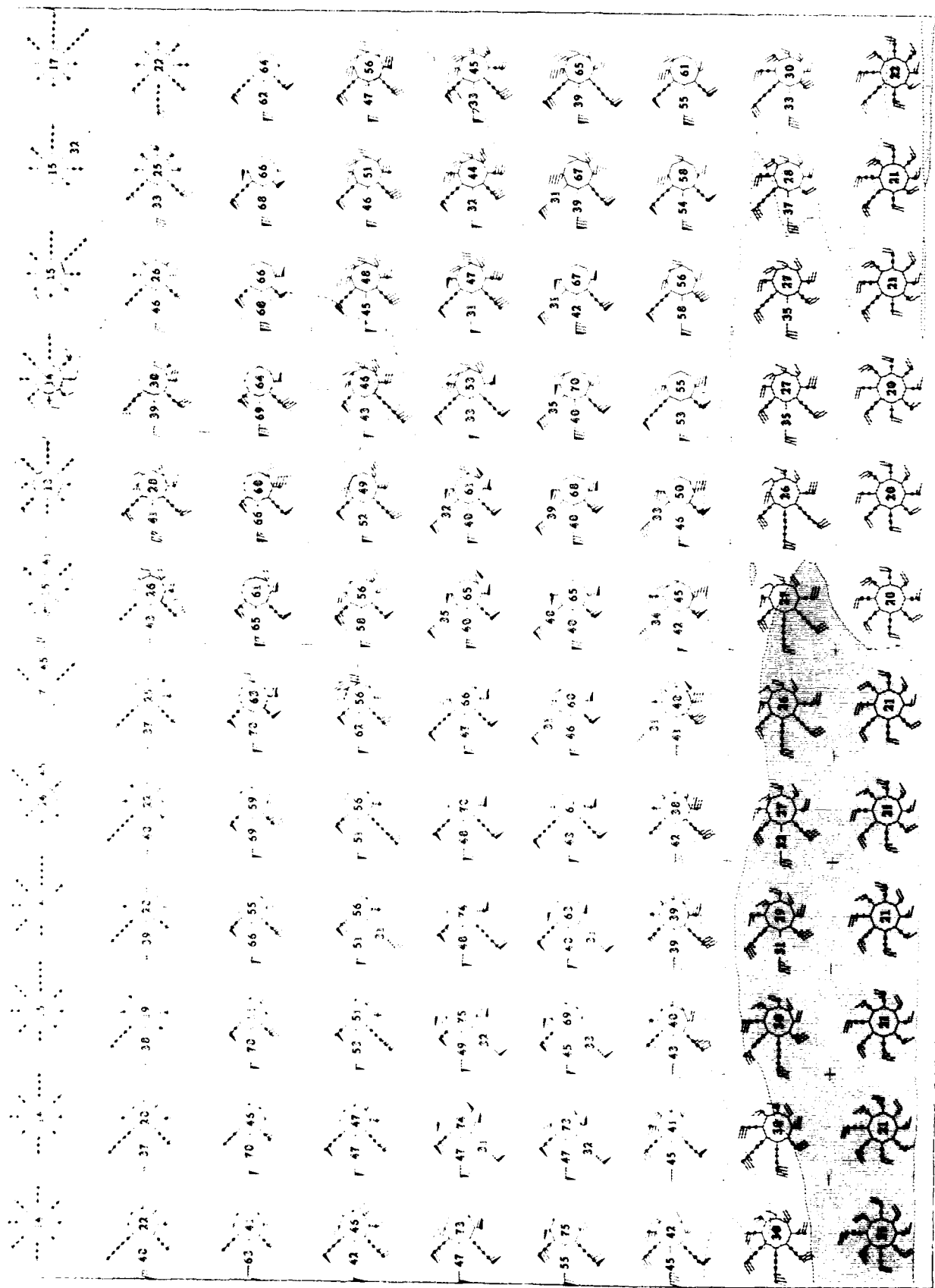




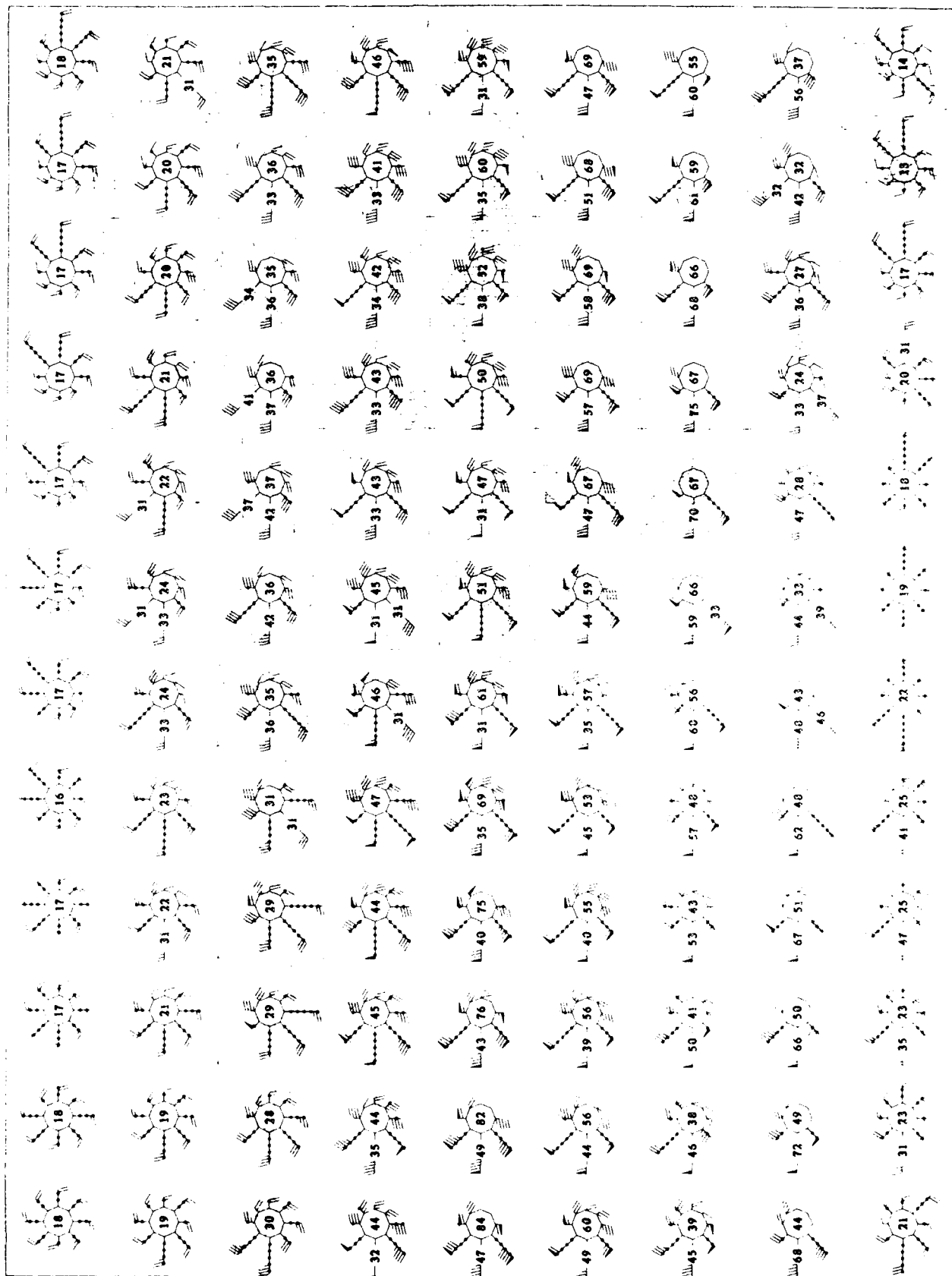
Upper Air Climatology
Southern Hemisphere

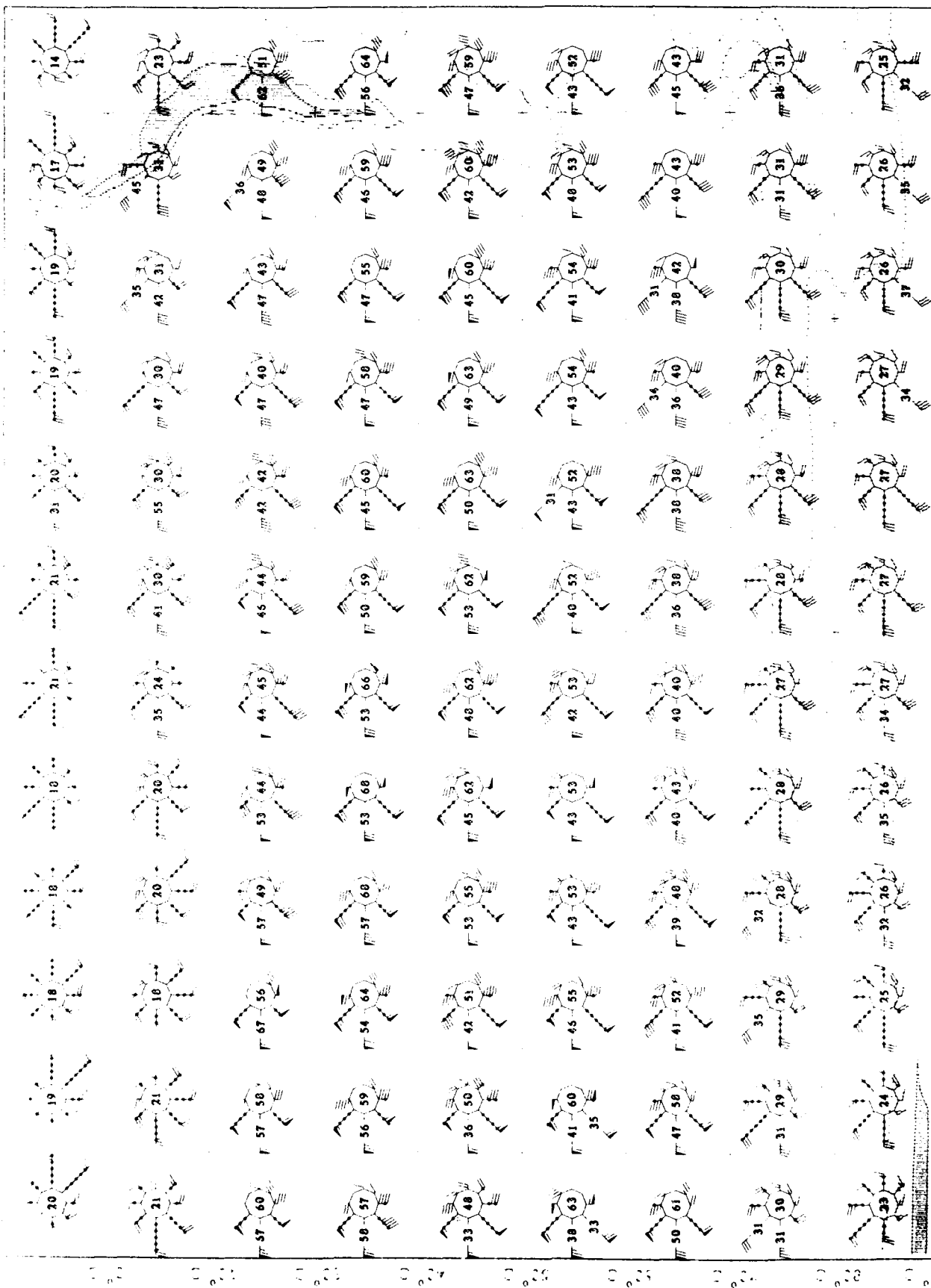
April 1953
250 MB





Upper Air Climatology
Southern Hemisphere

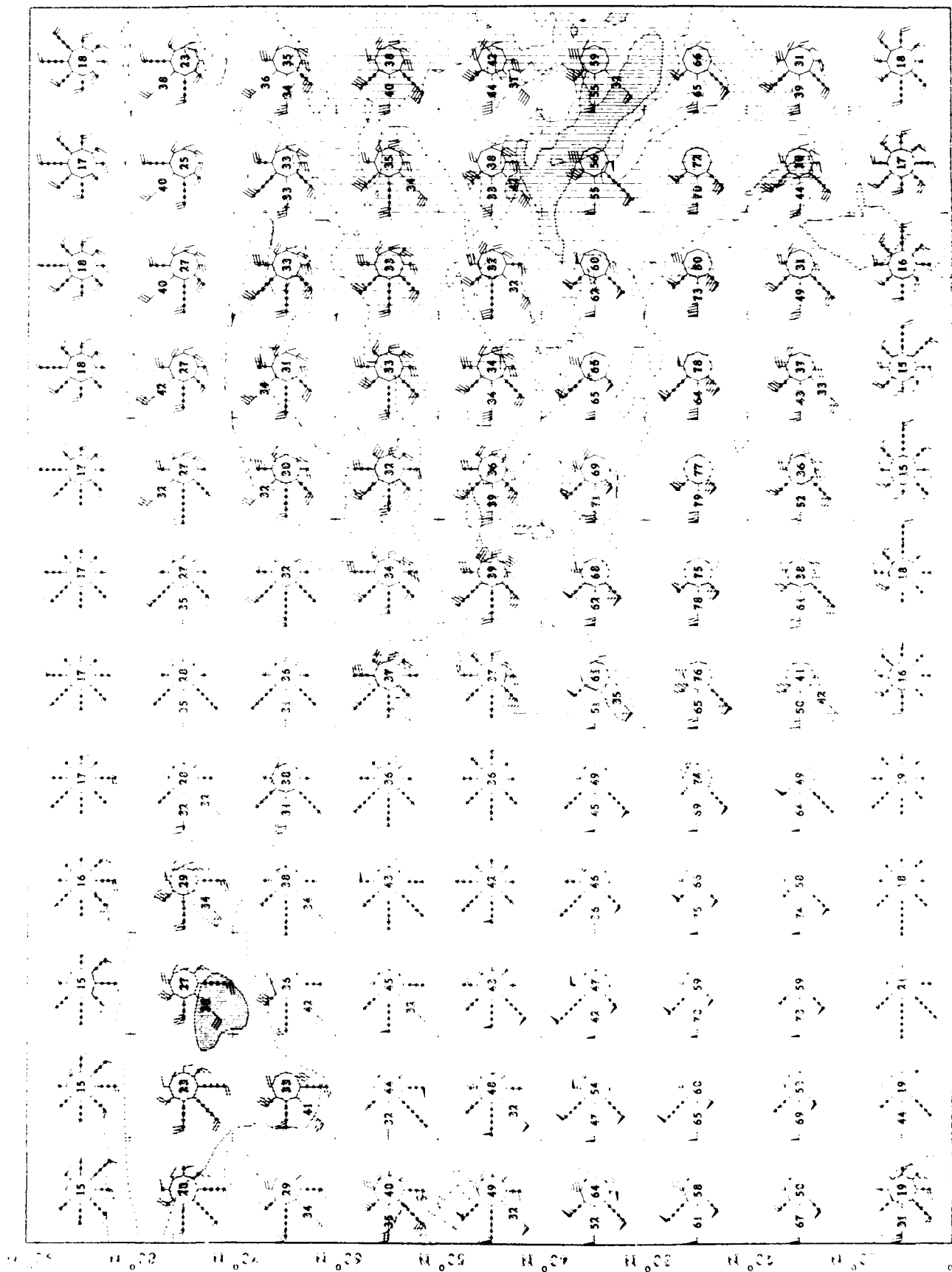


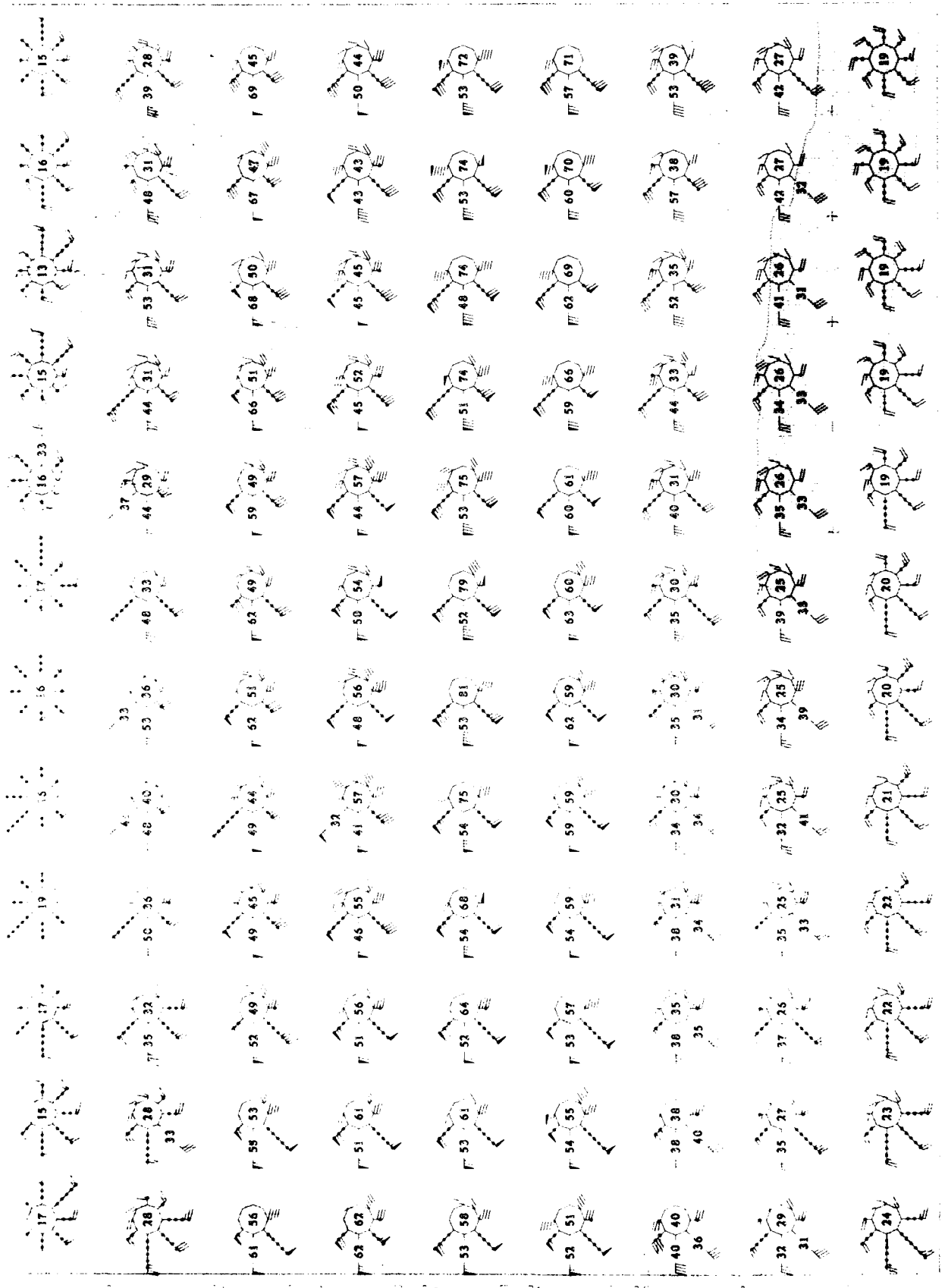


Upper Air Climatology
Geothermal Heliosphere

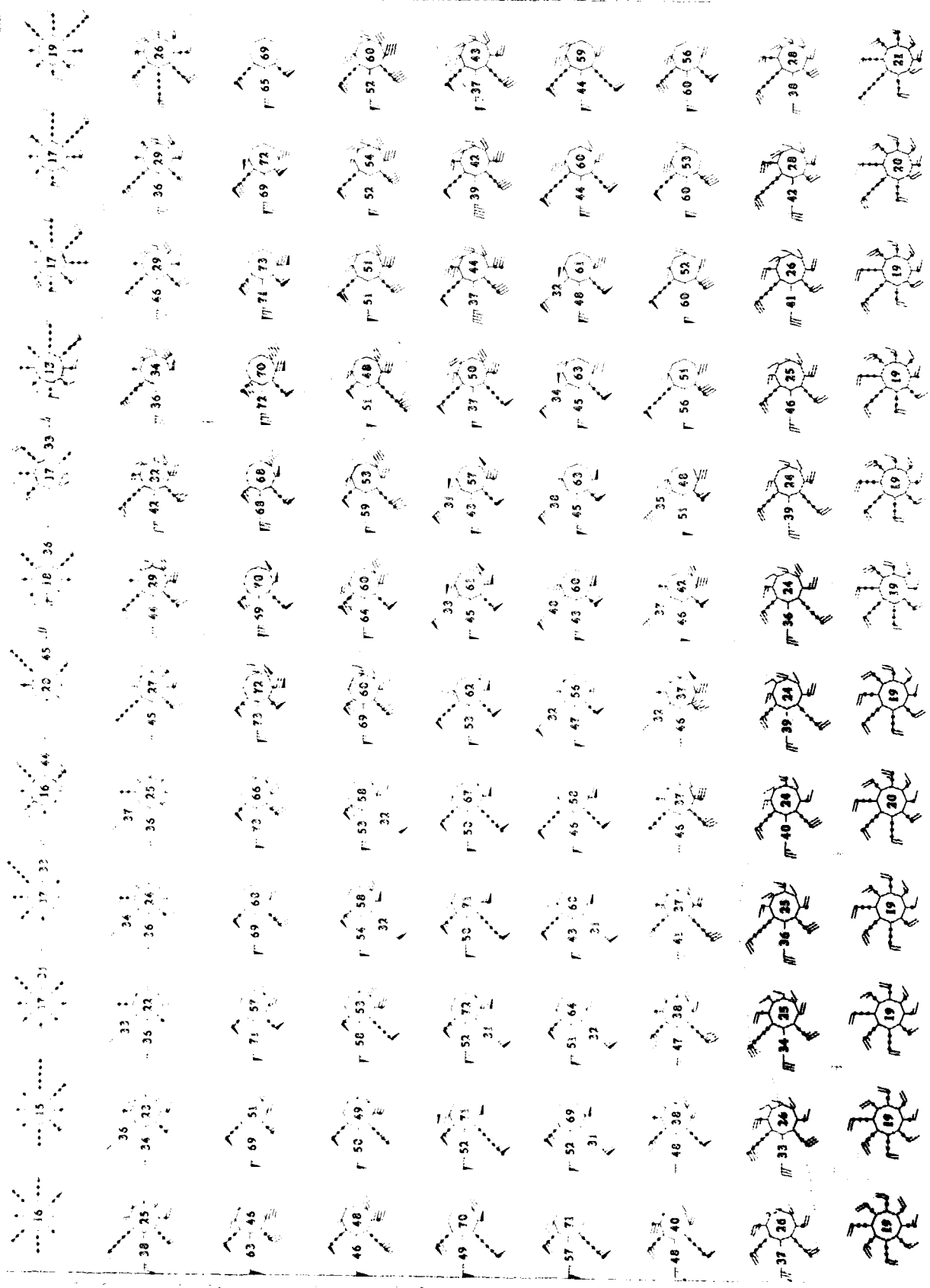
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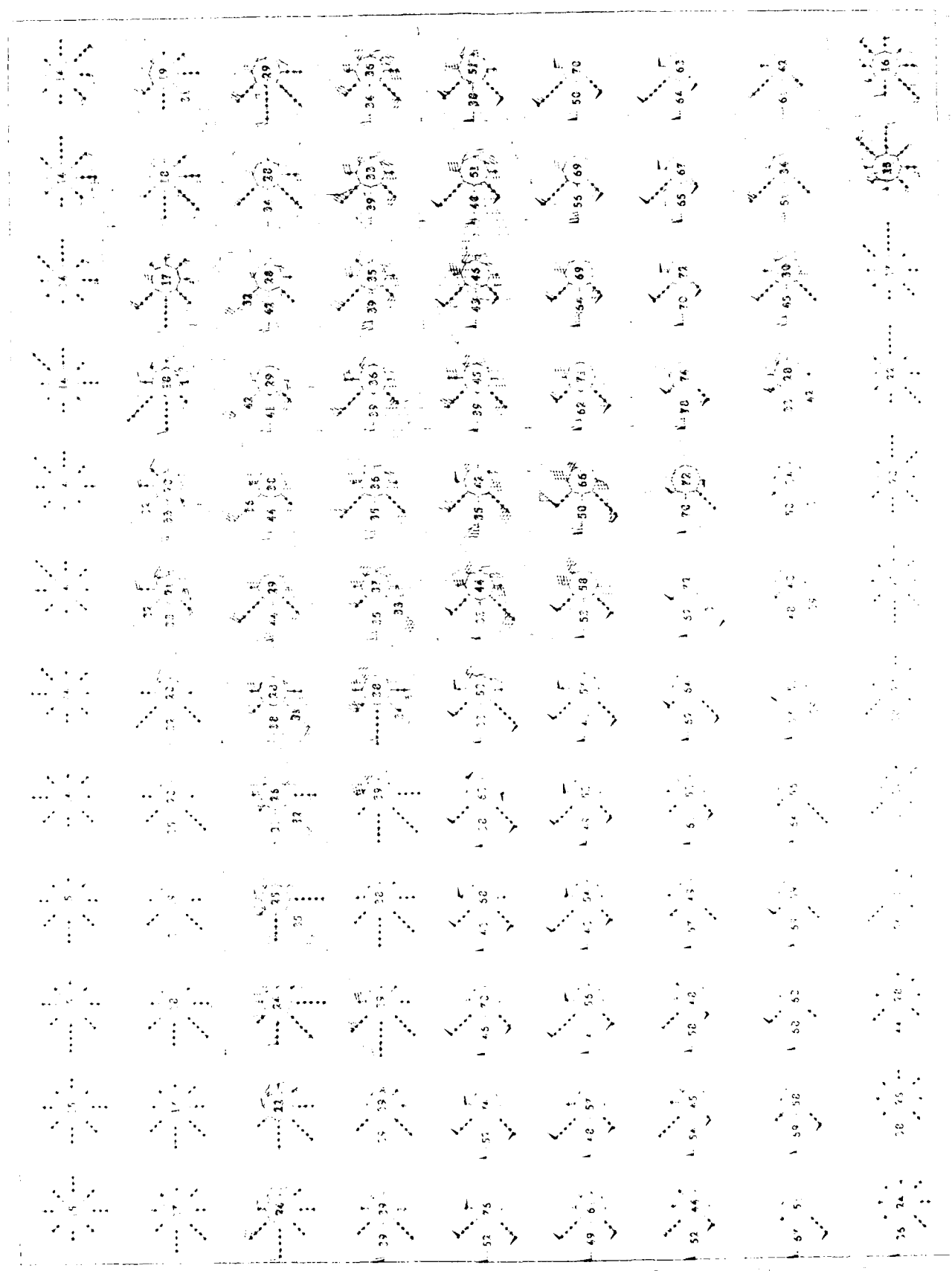
Apr 61
250 M2

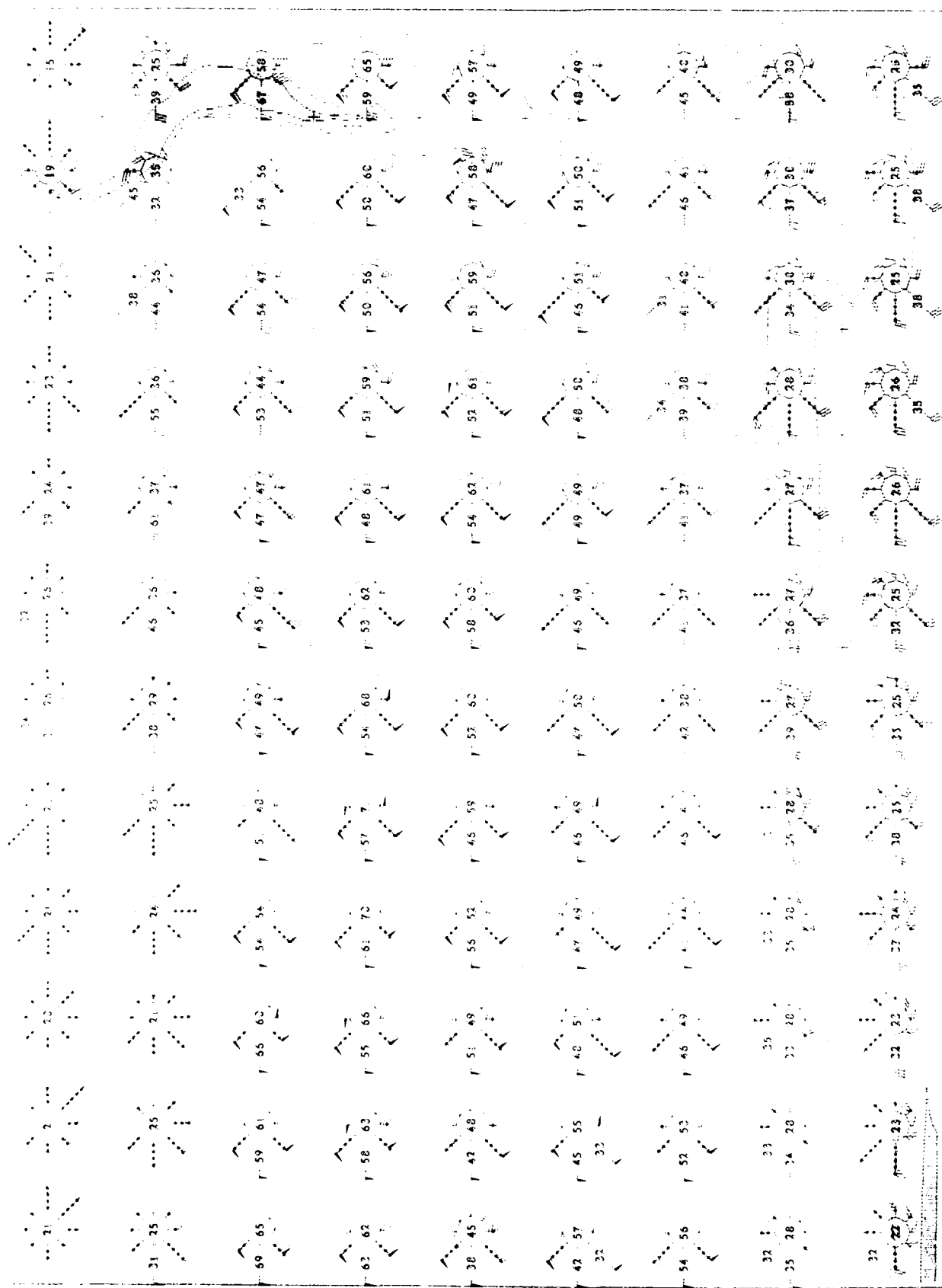


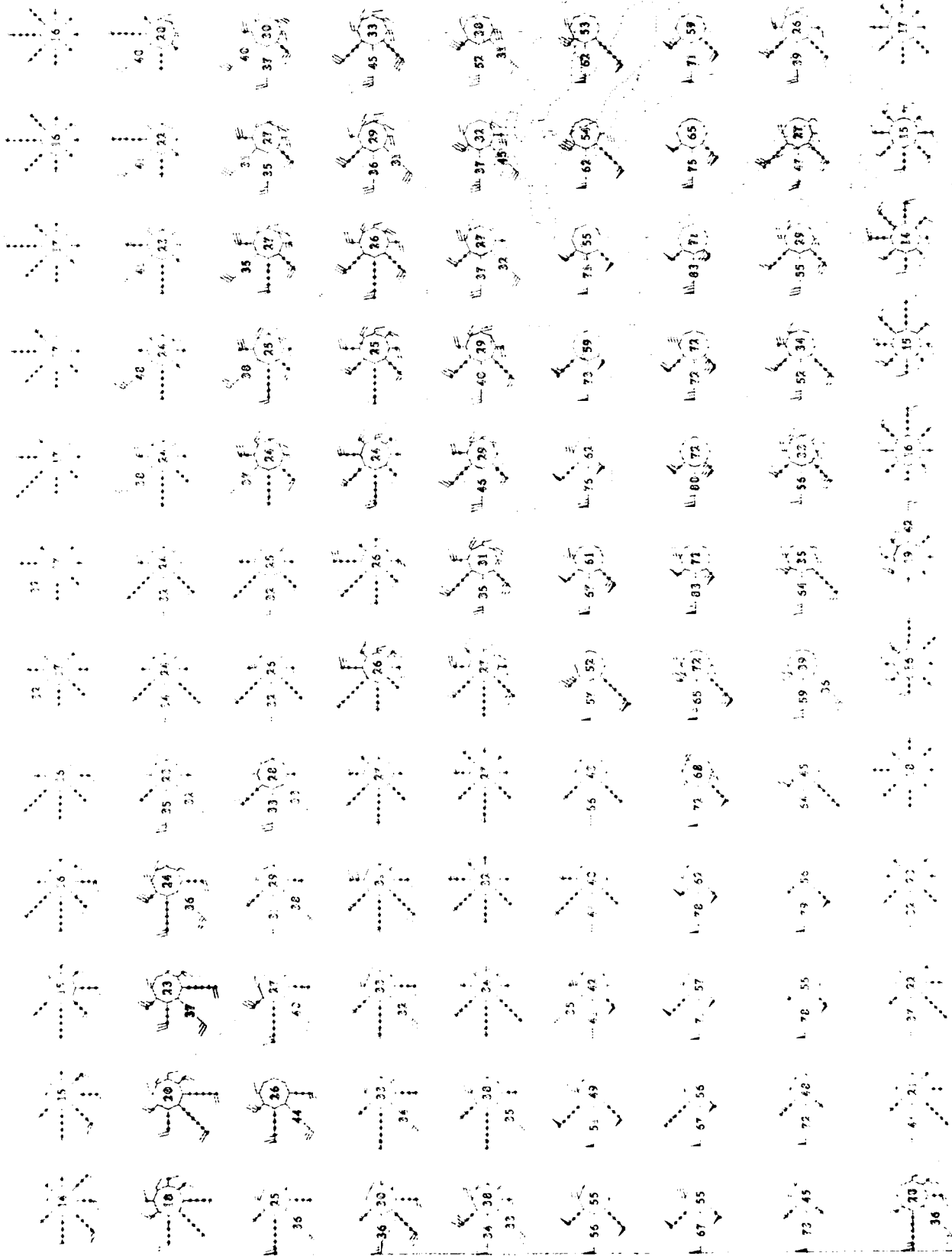


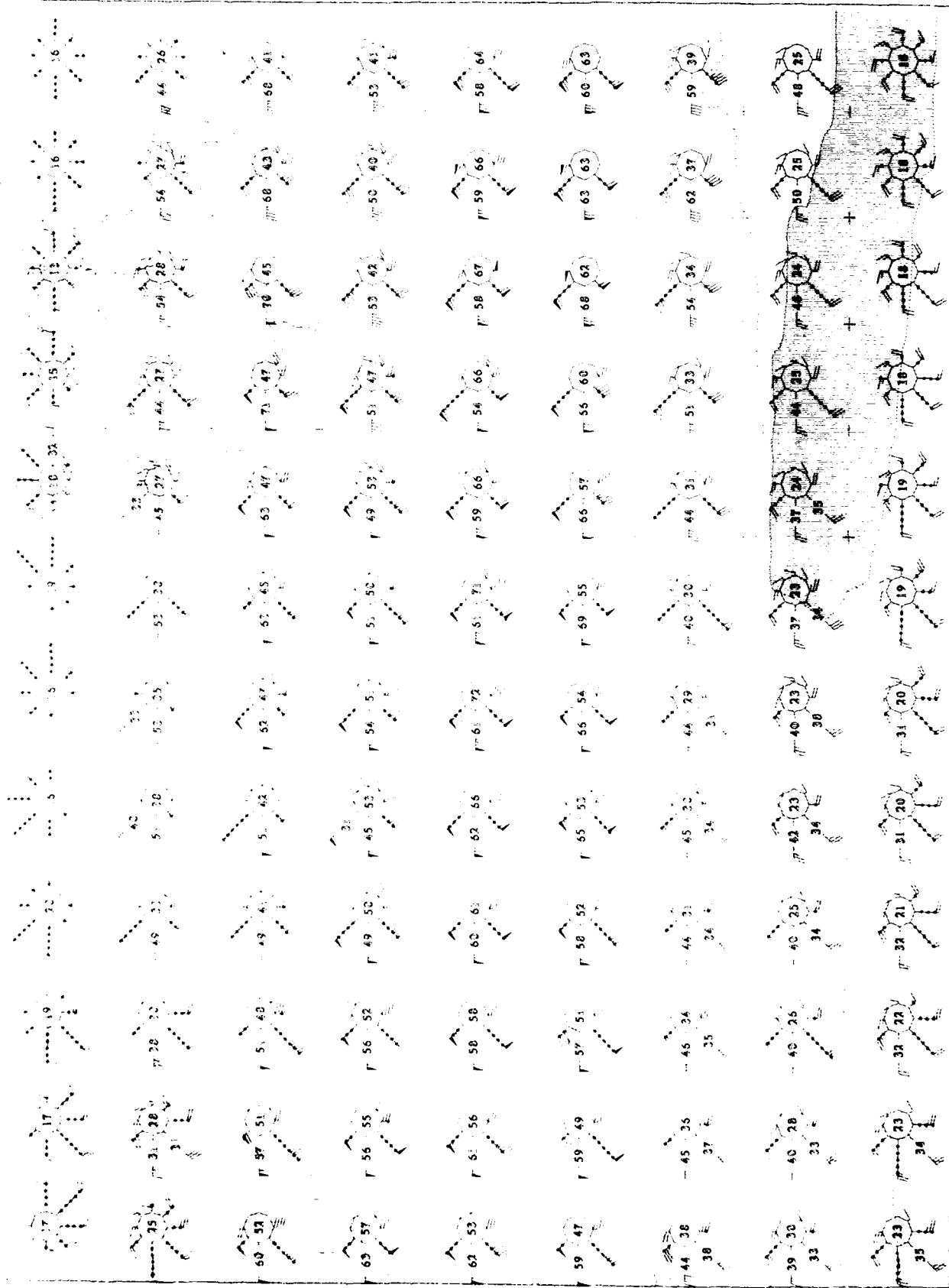








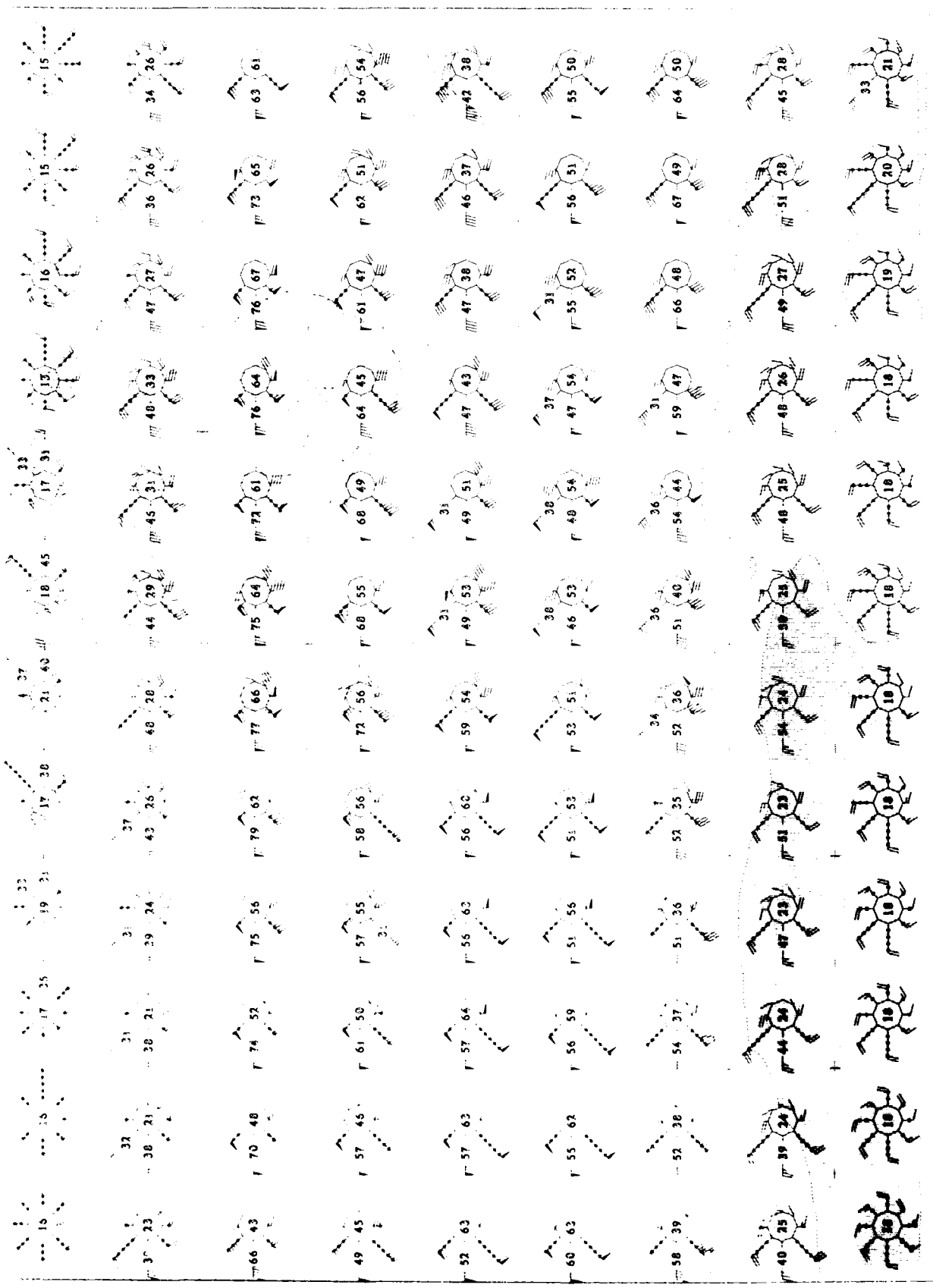




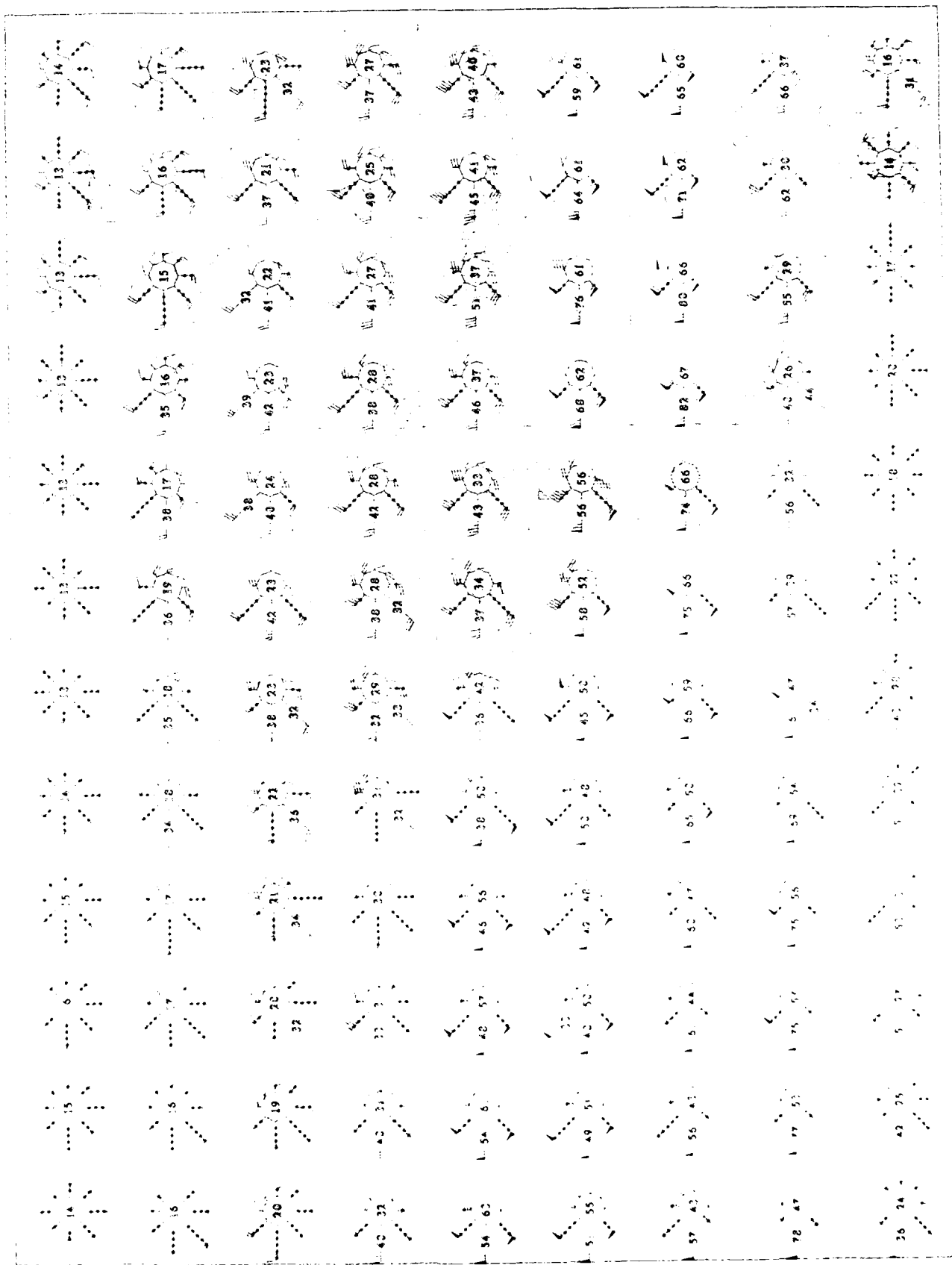
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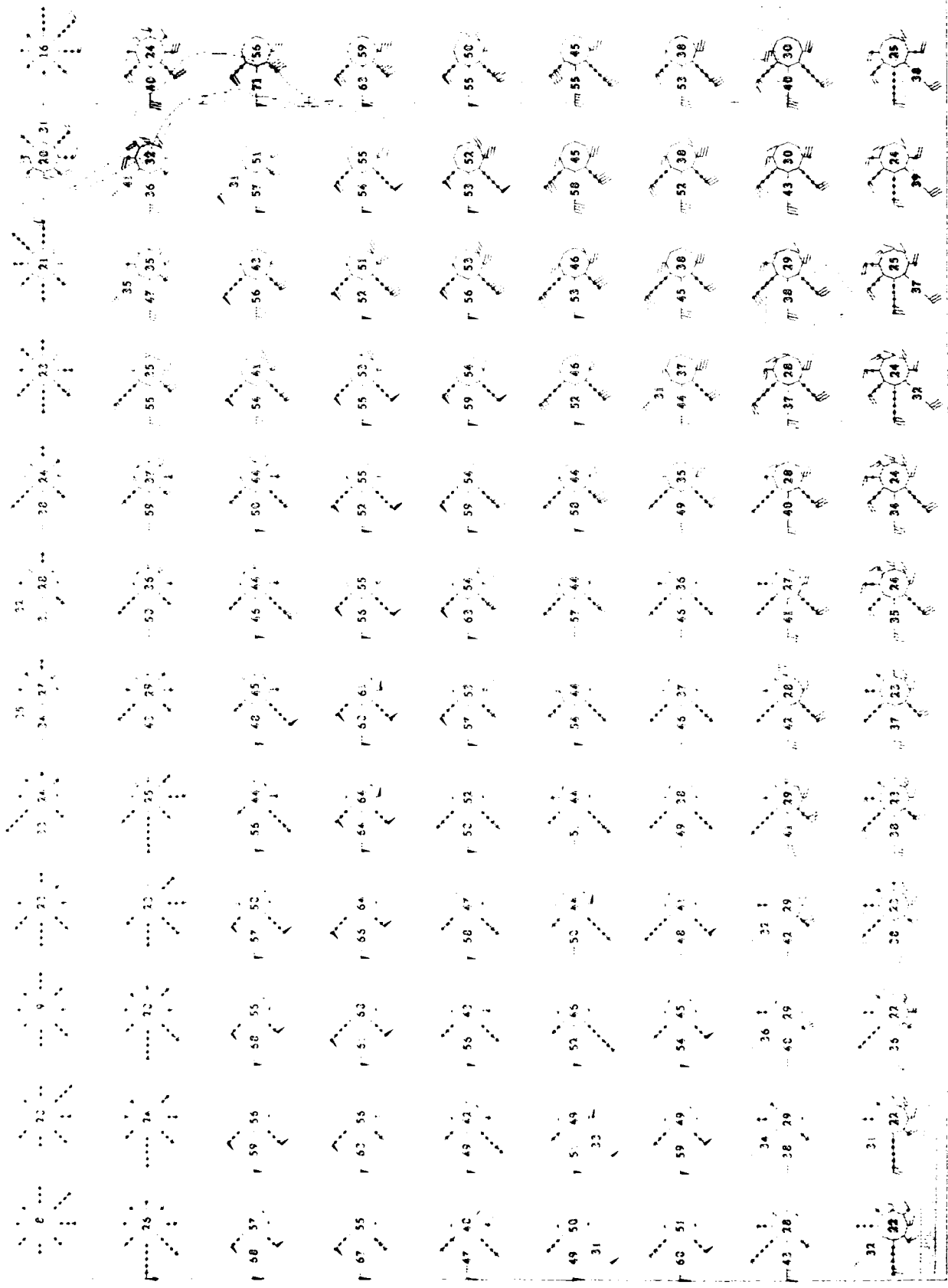
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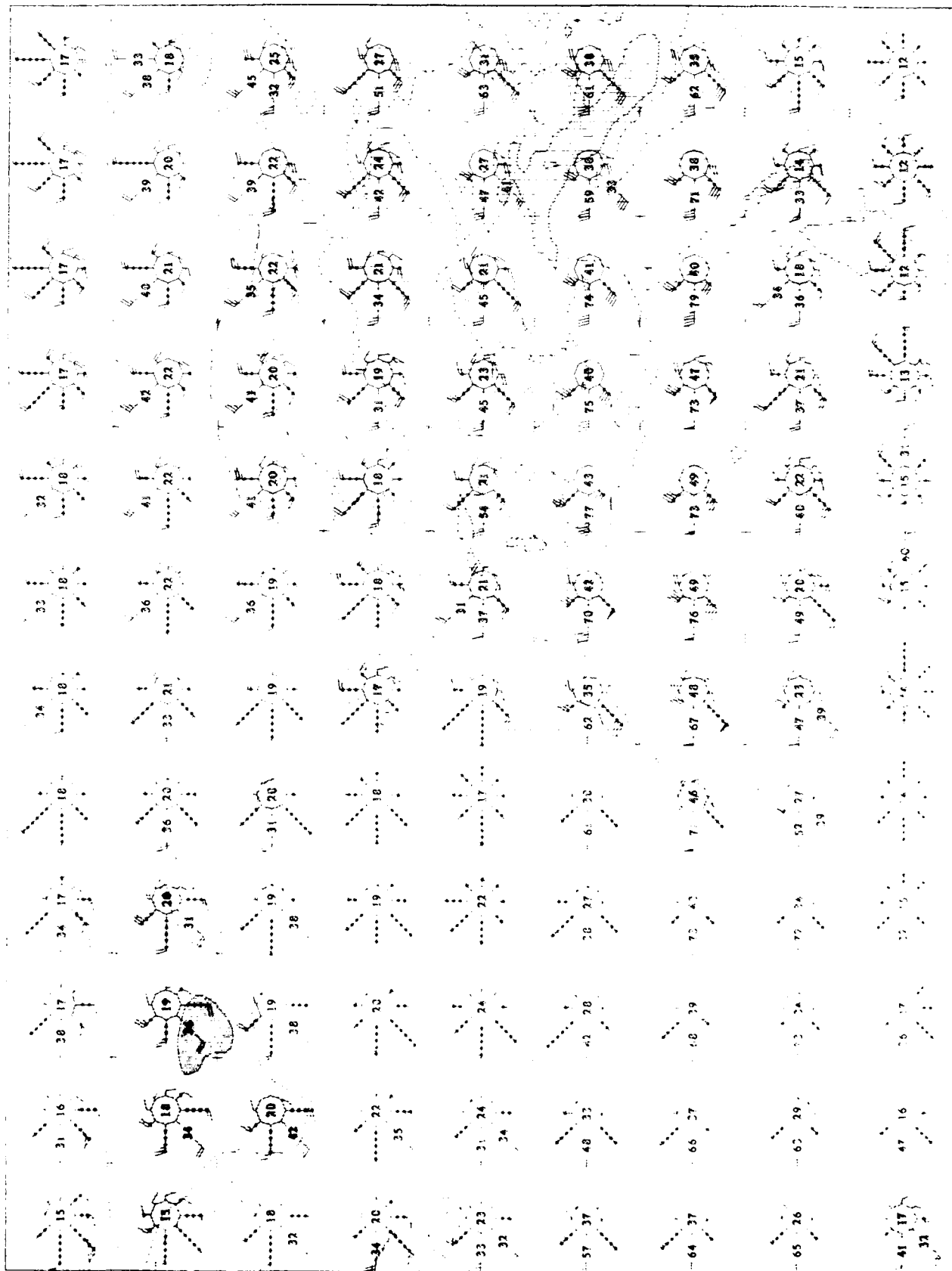


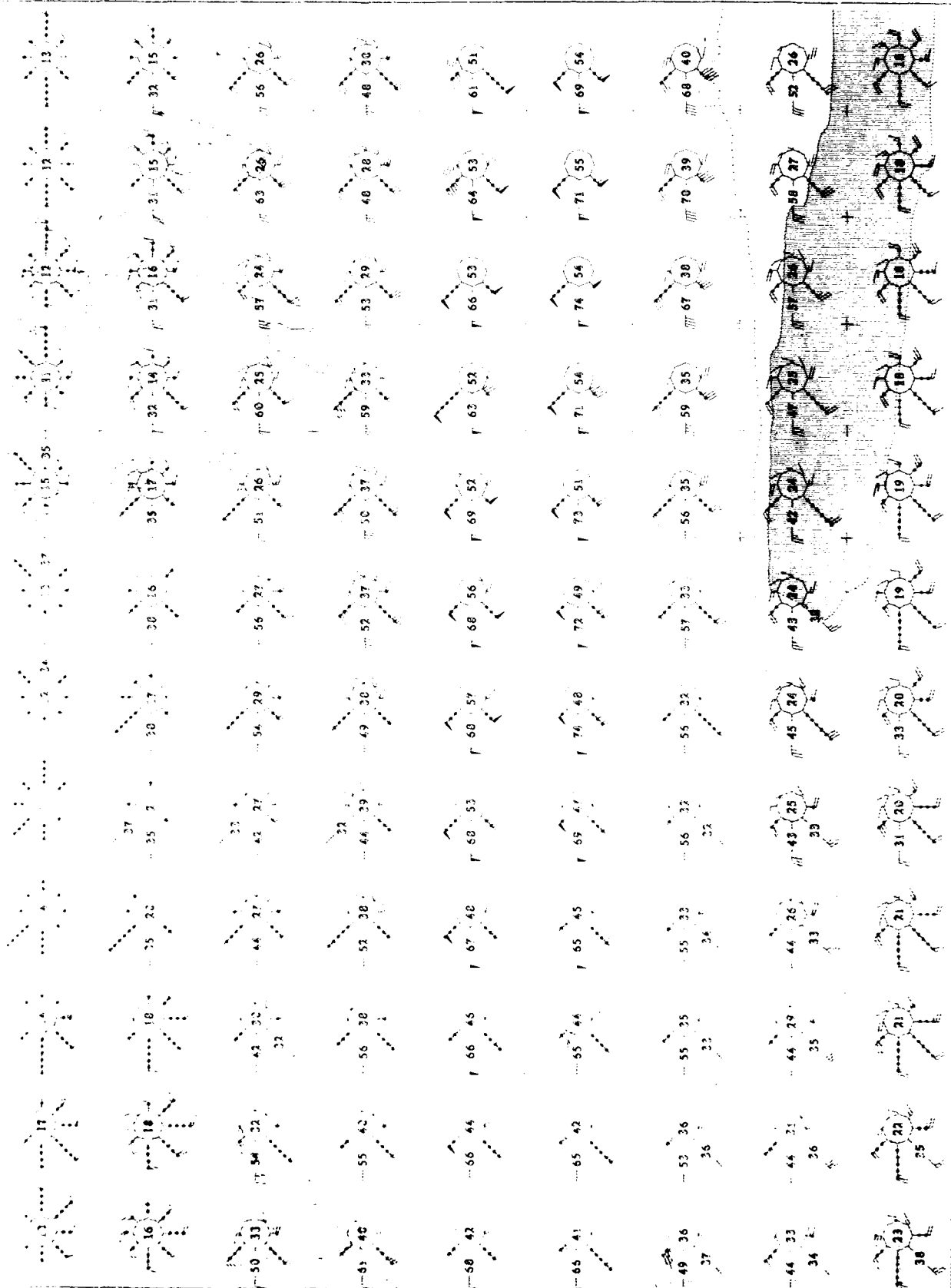
Upper Arm Climb
 Overhead Hamstring





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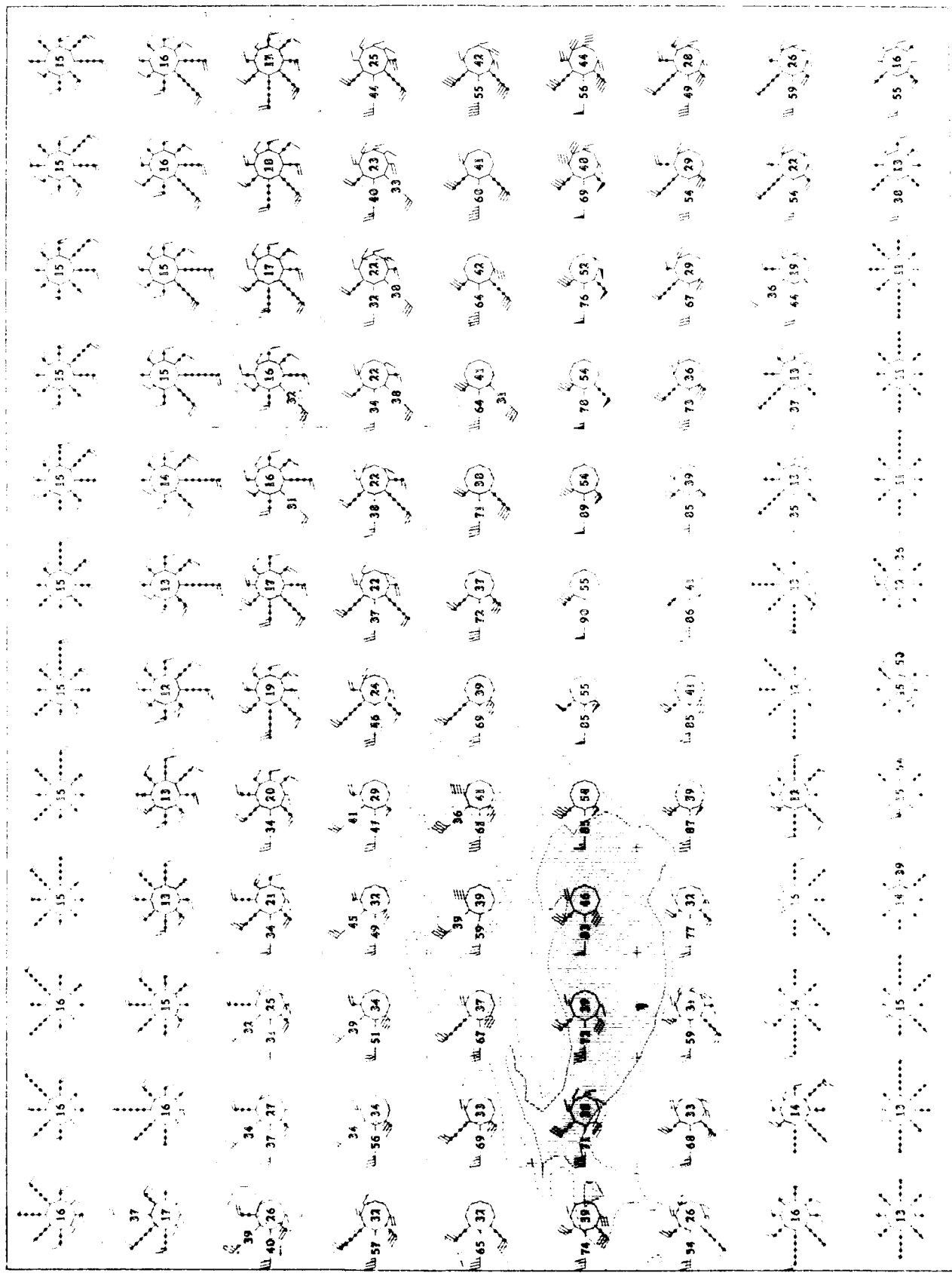


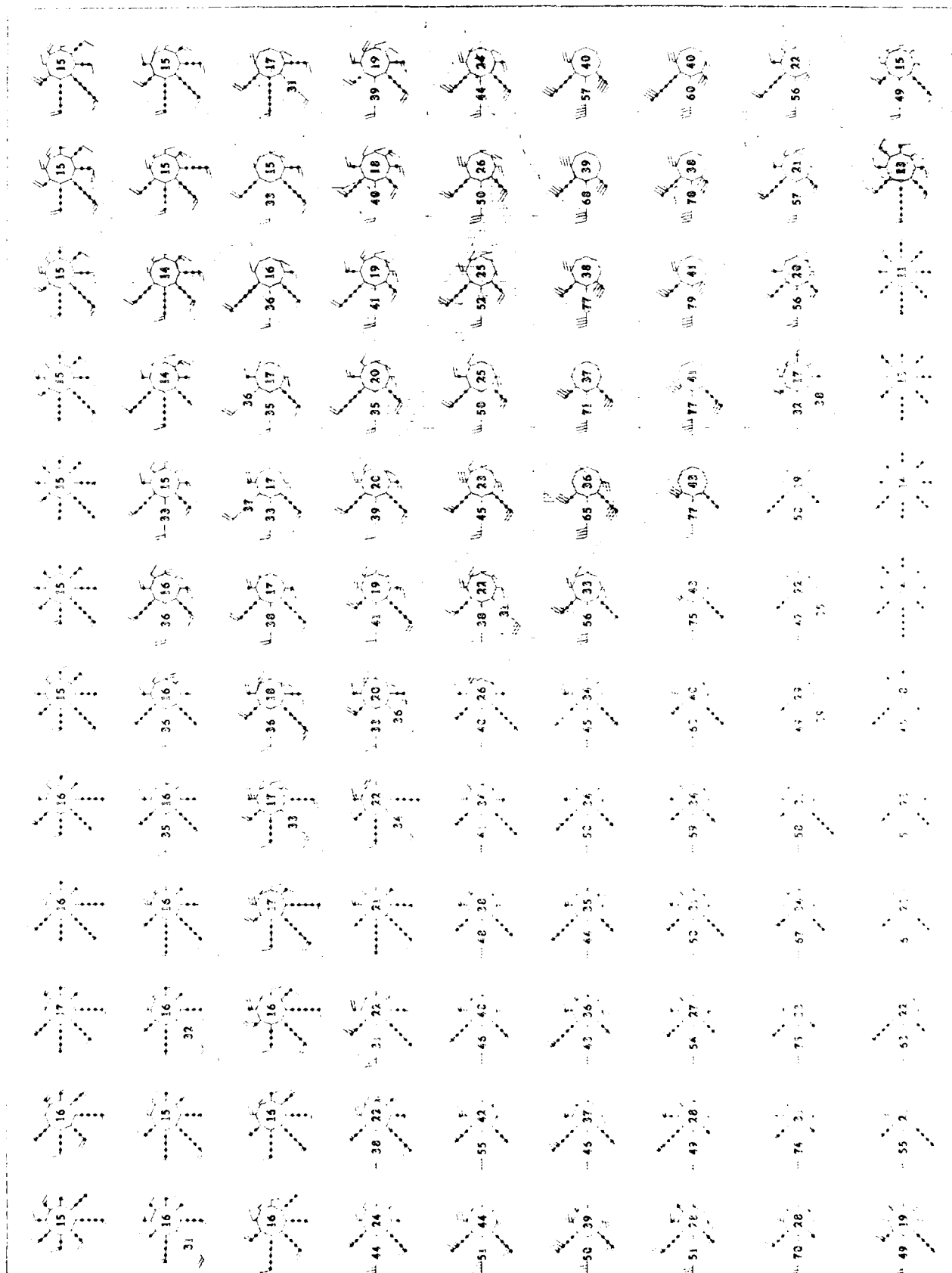


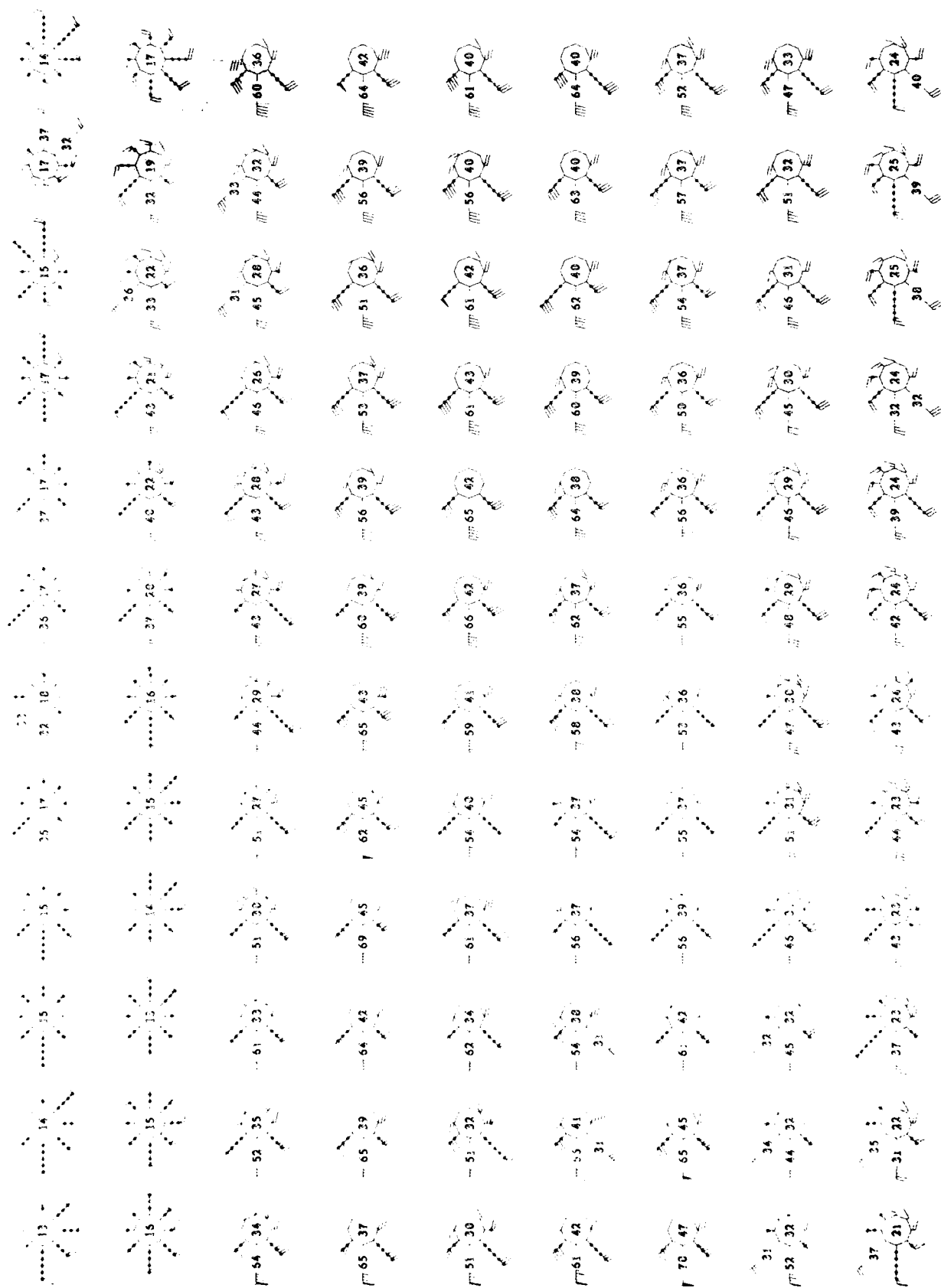
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of the spiders in the
columns and rows.

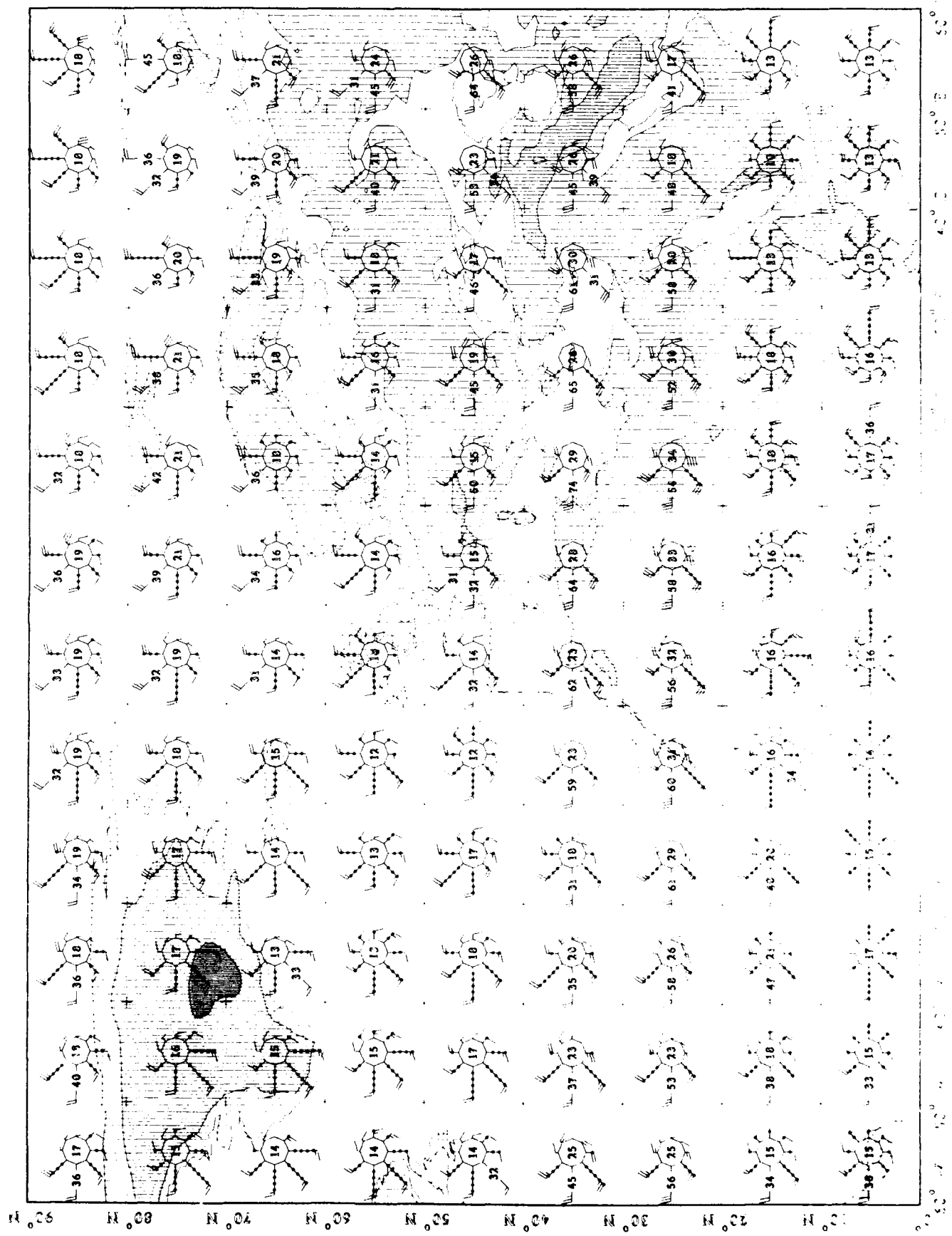
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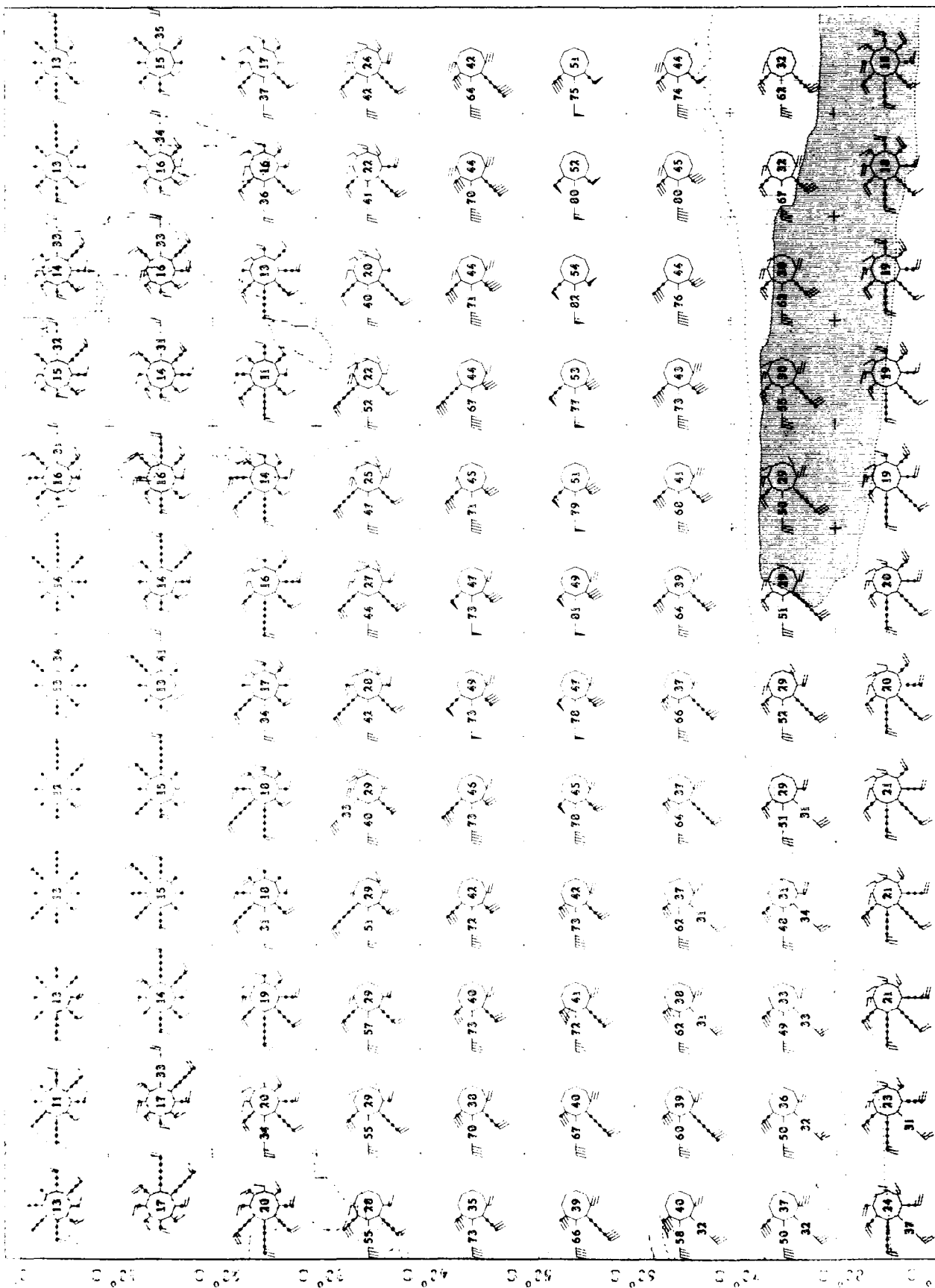
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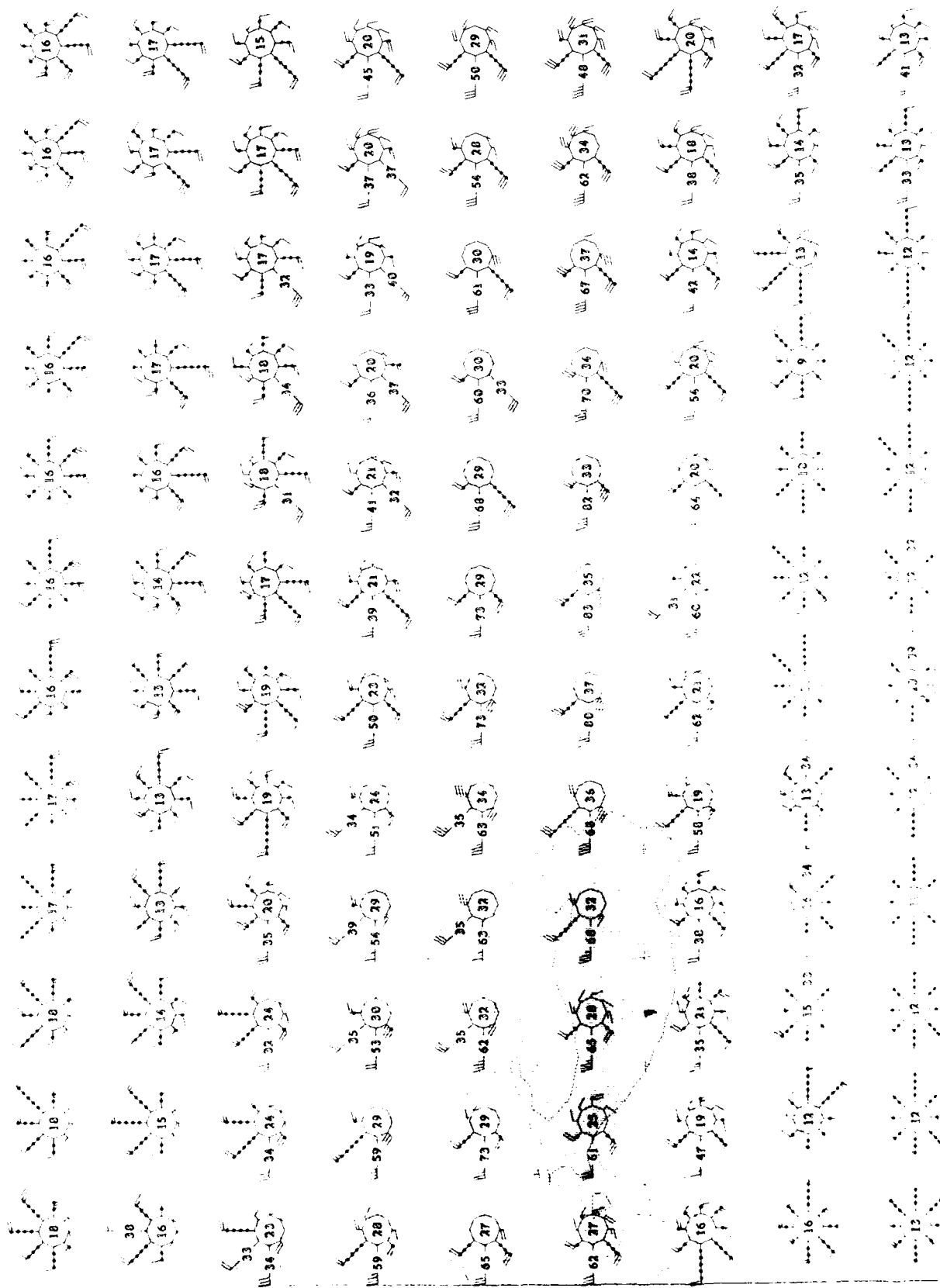






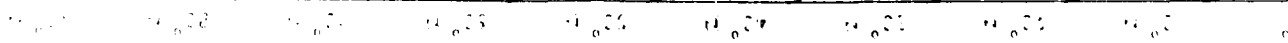


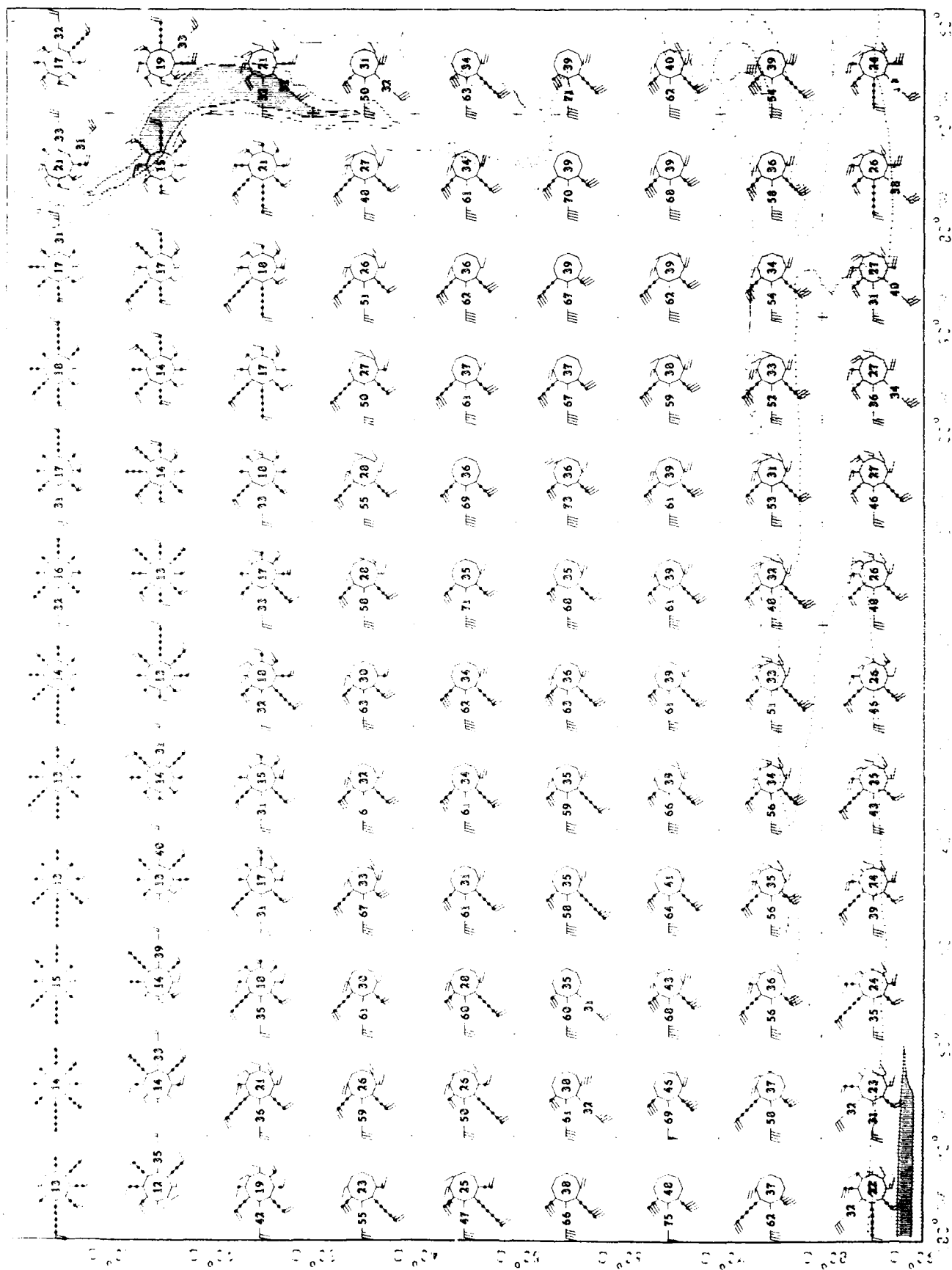




April 20 1945



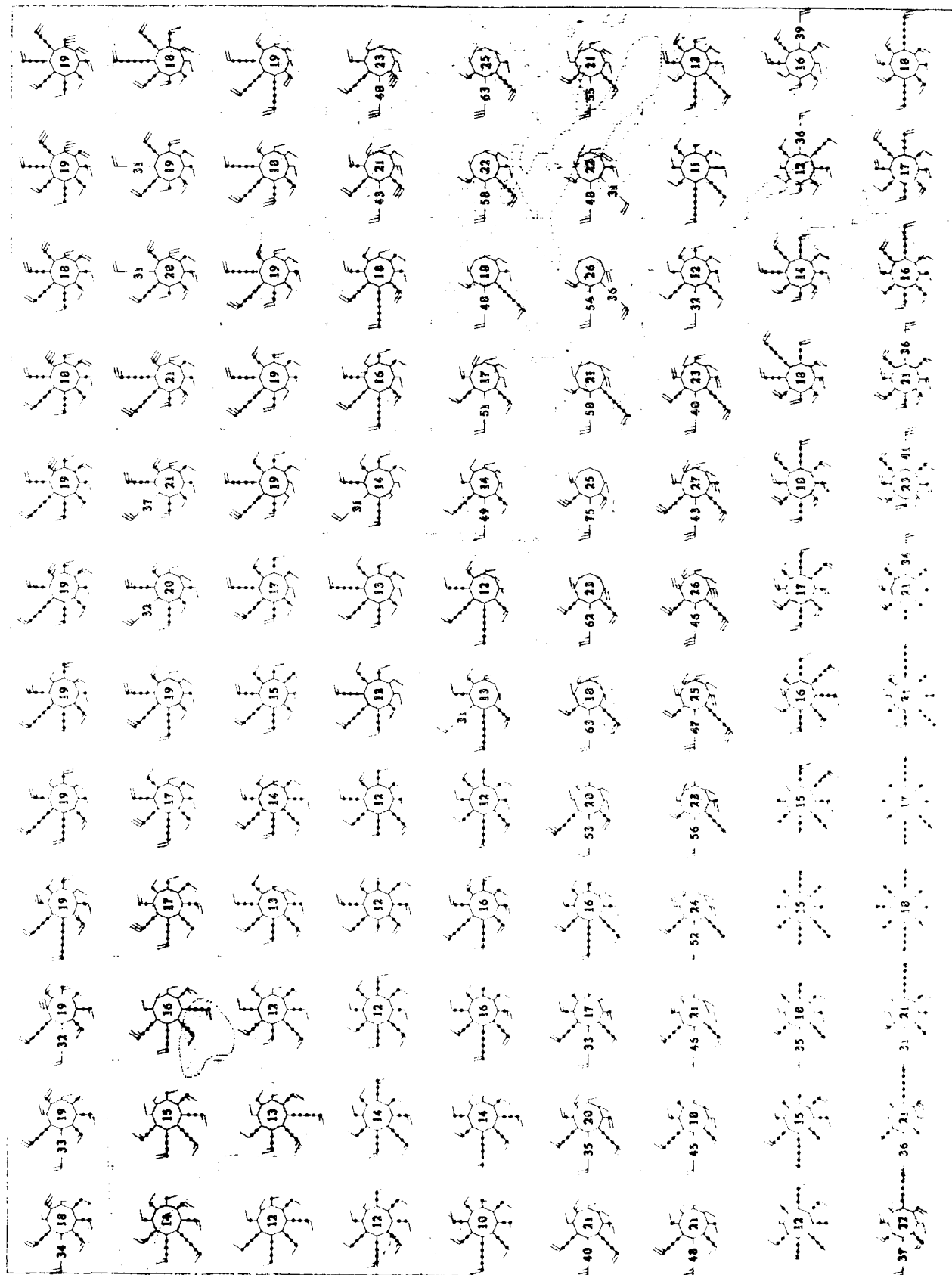


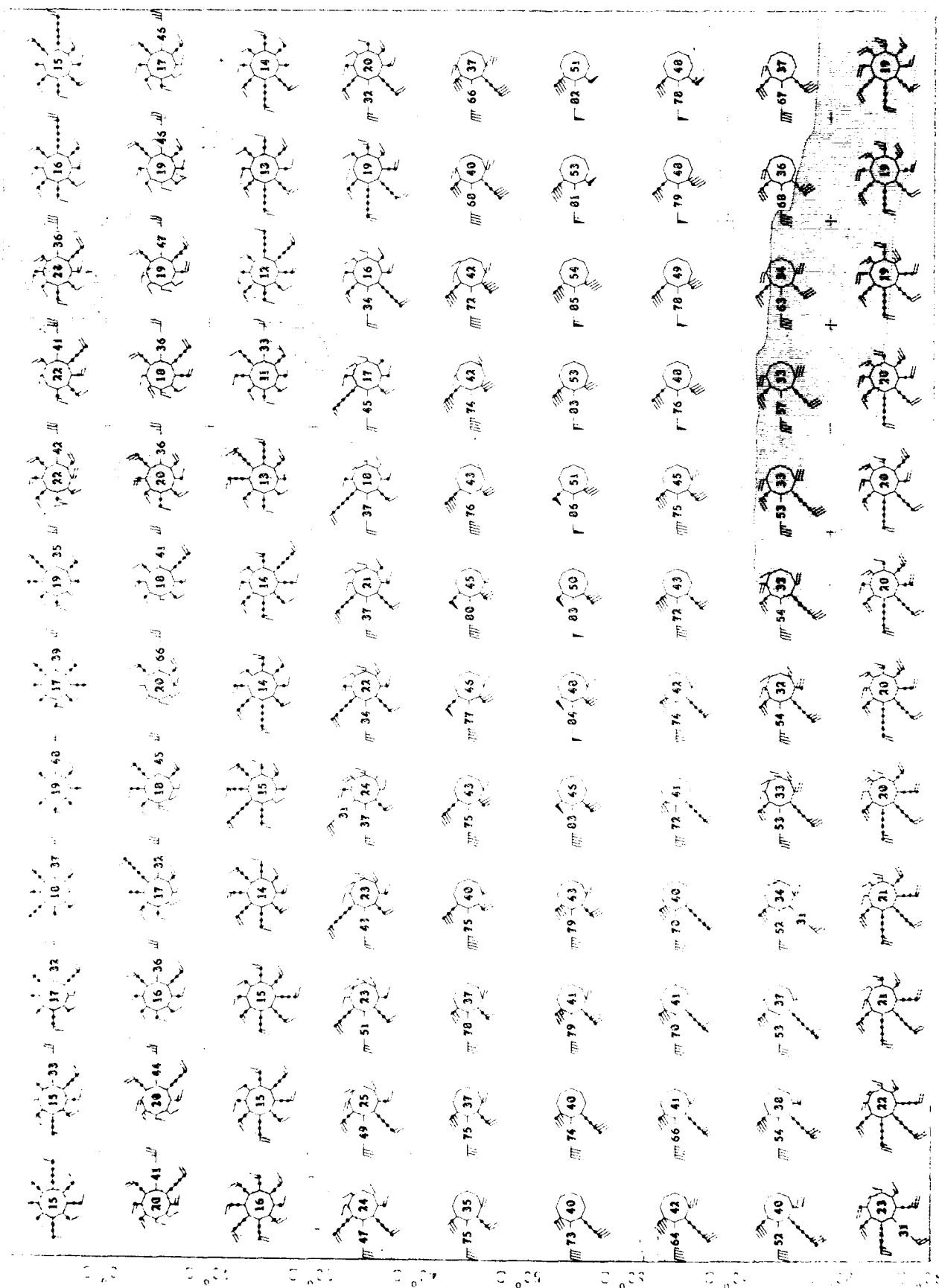


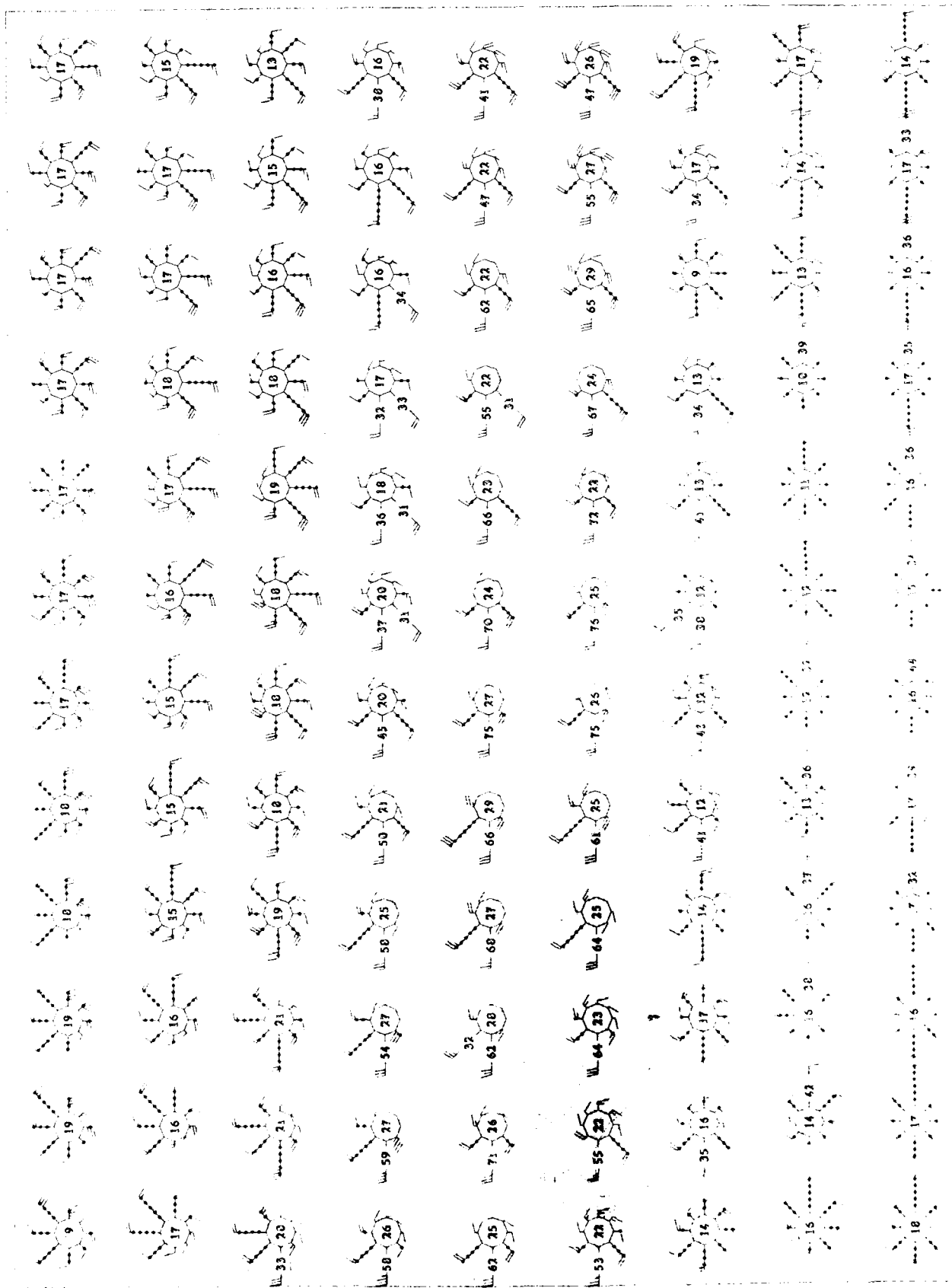
Types and Chemistry
Northern Hemisphere

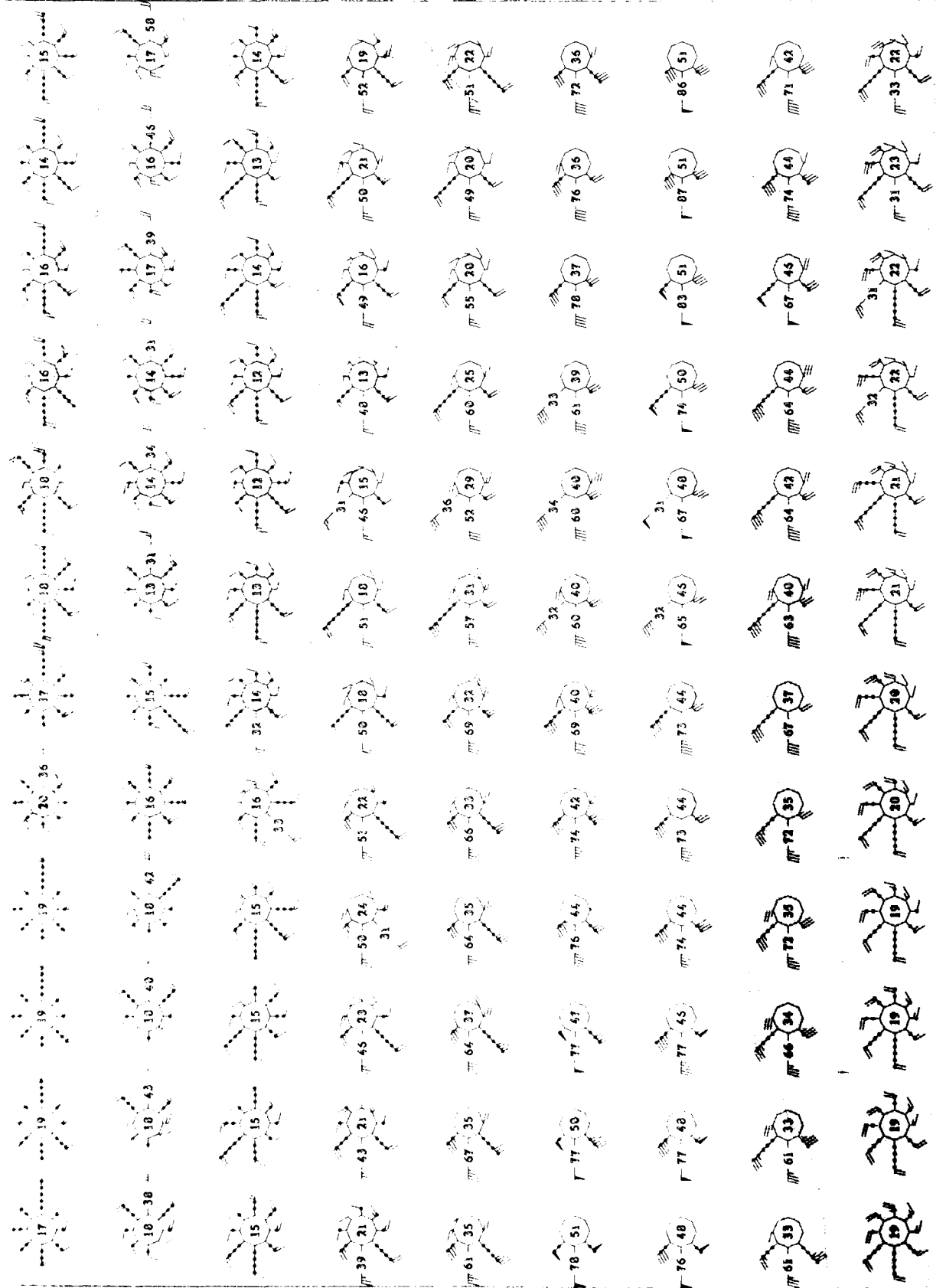
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5000-5000

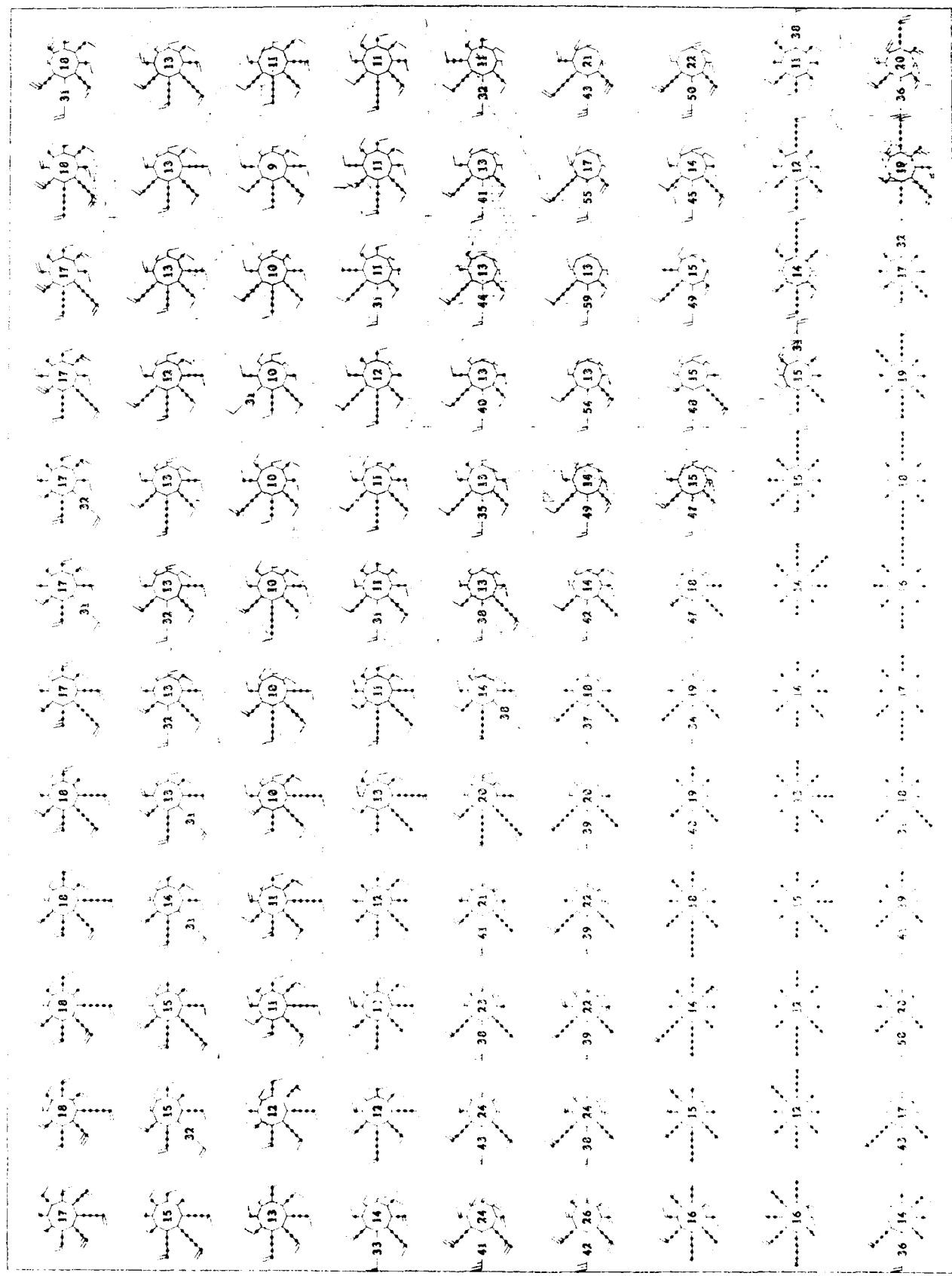
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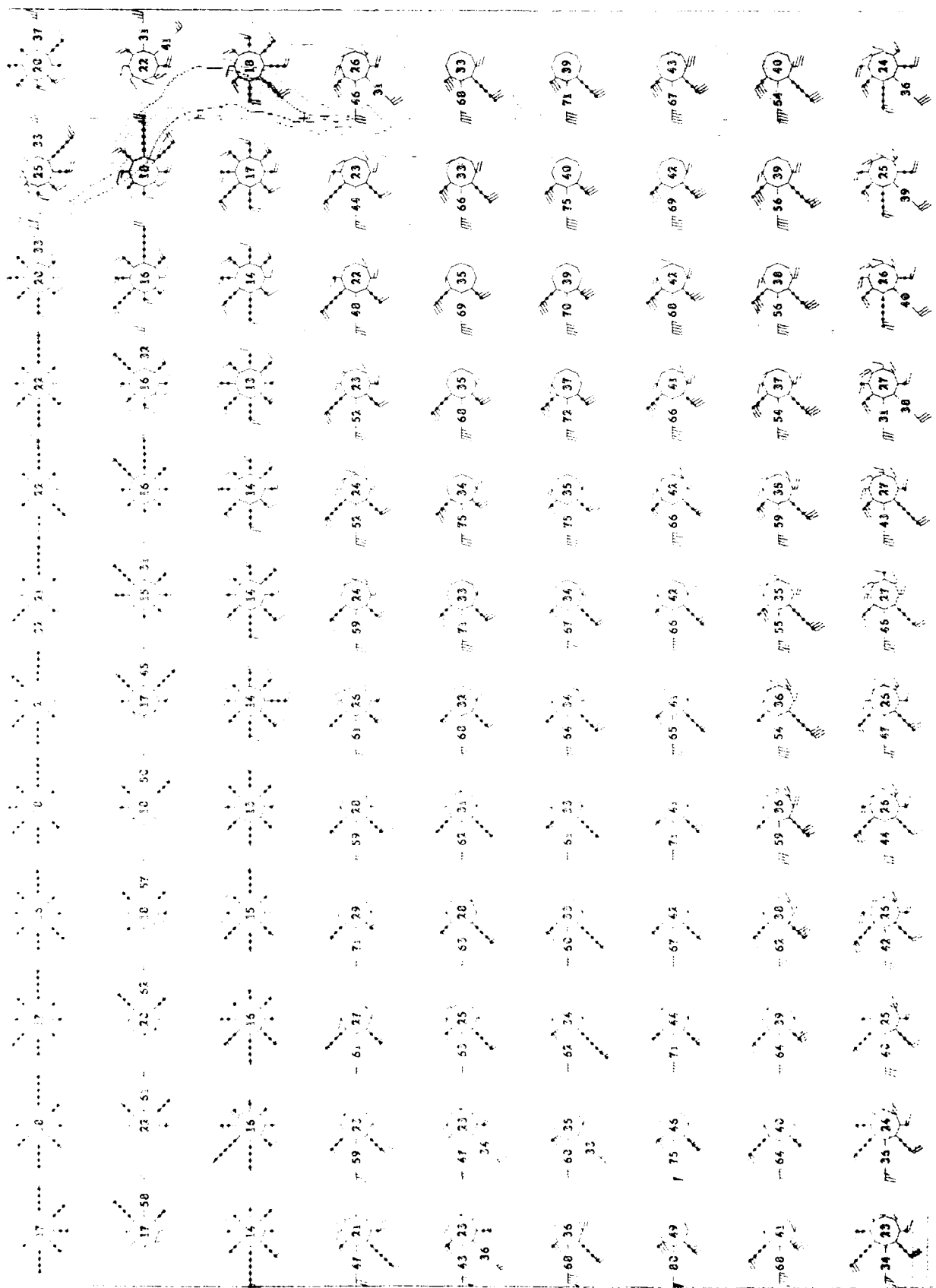


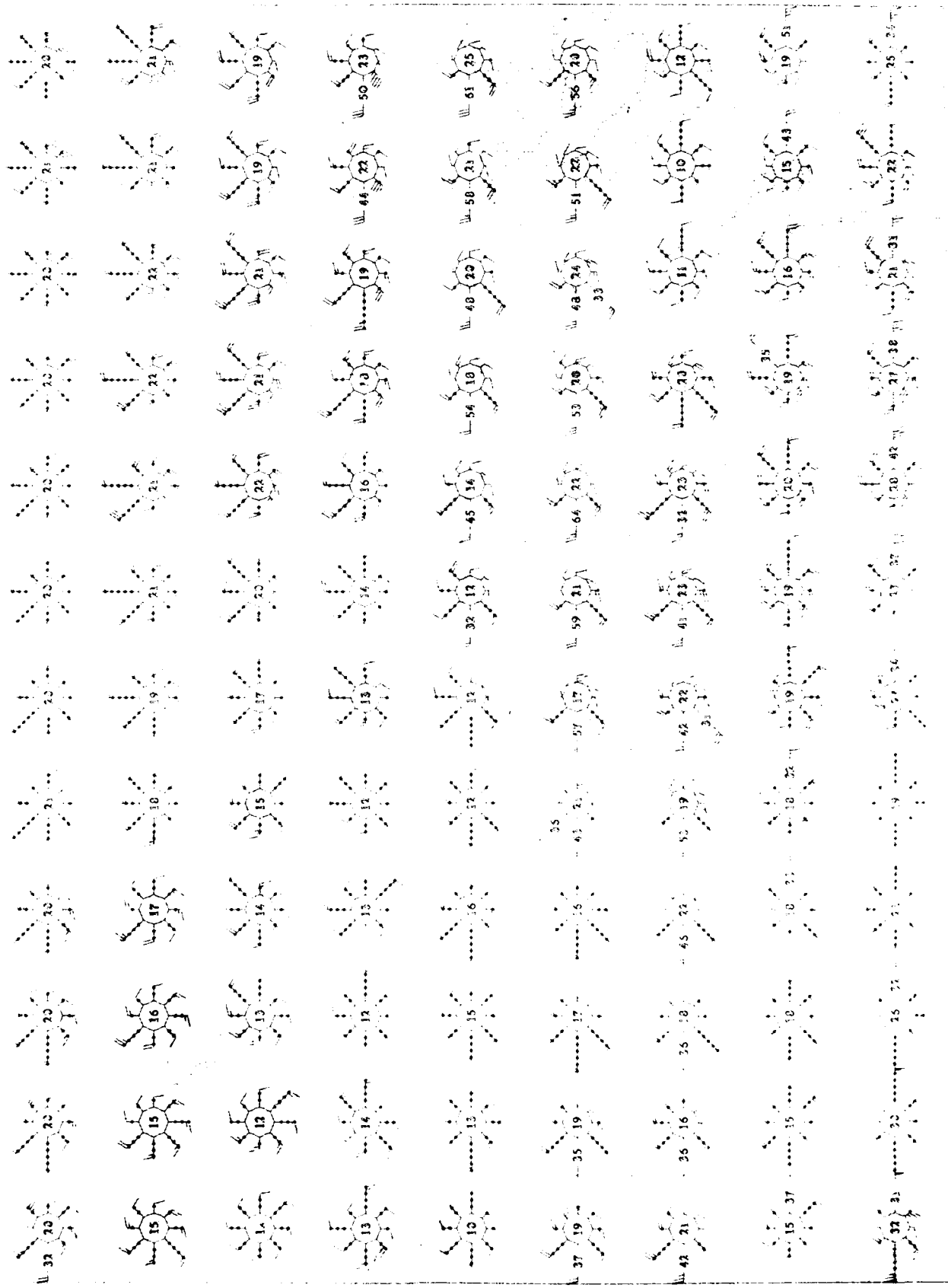


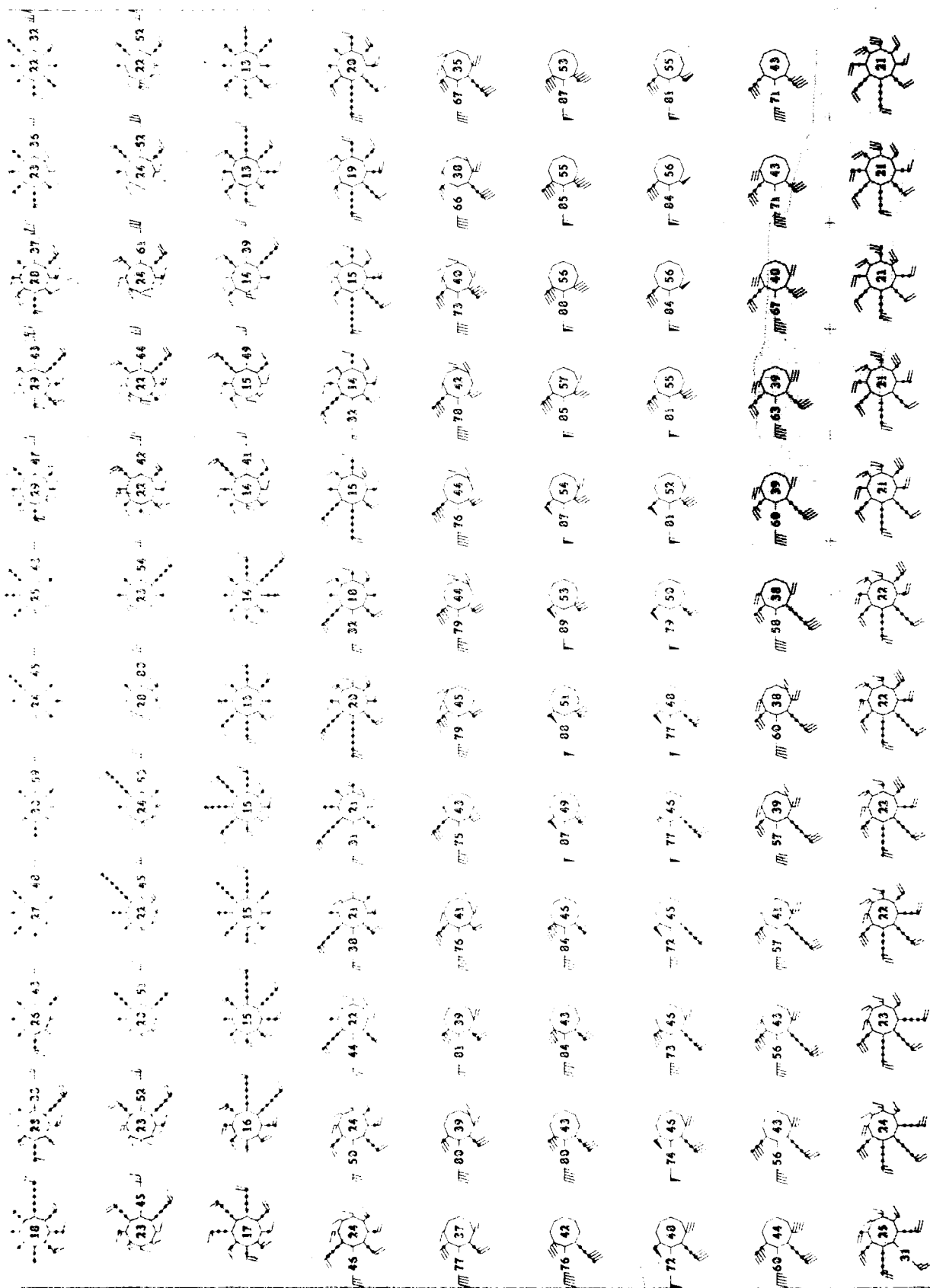












Upper Air Climatology
Geothora, Hainan

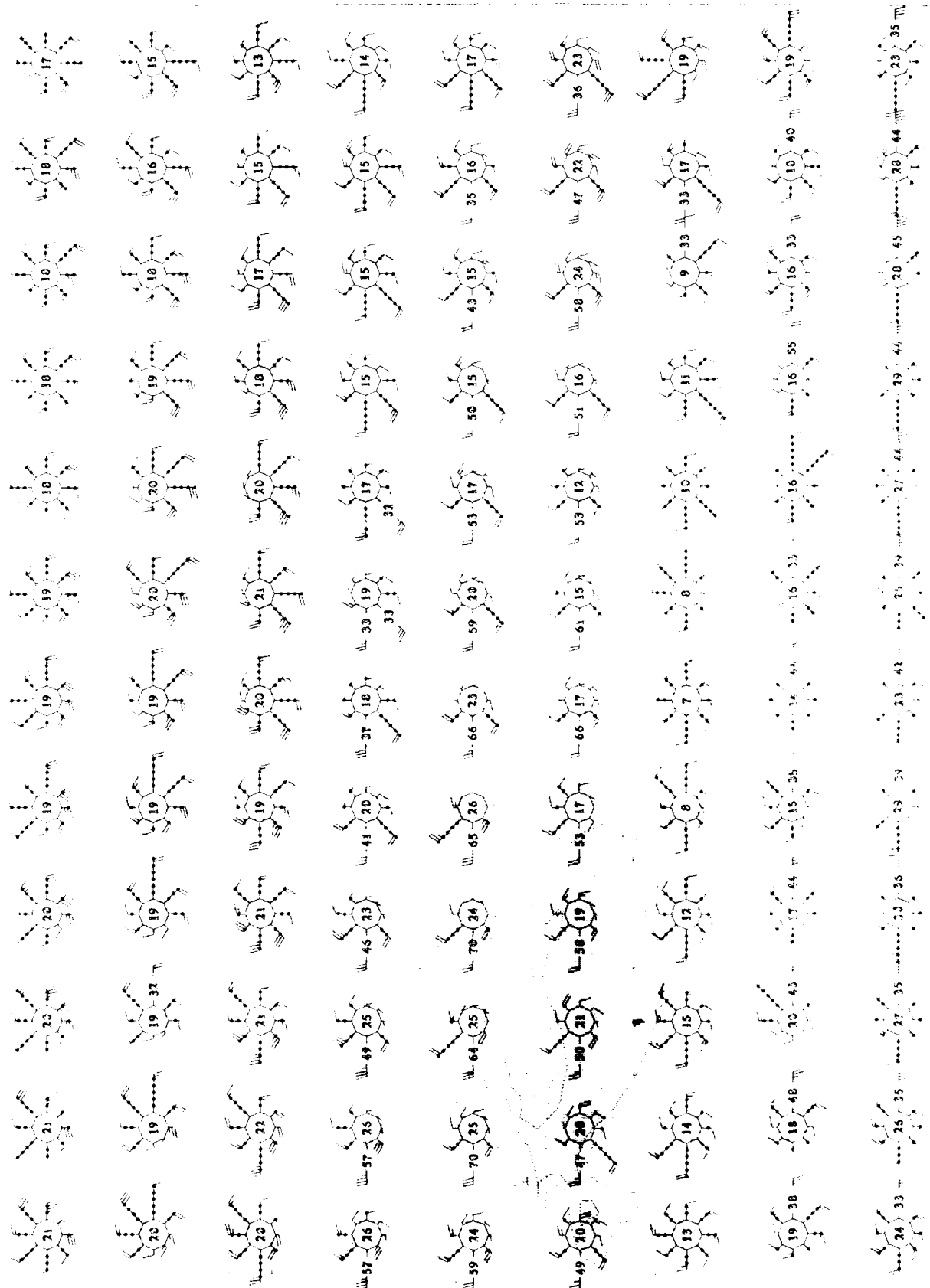
5. 10. 1950

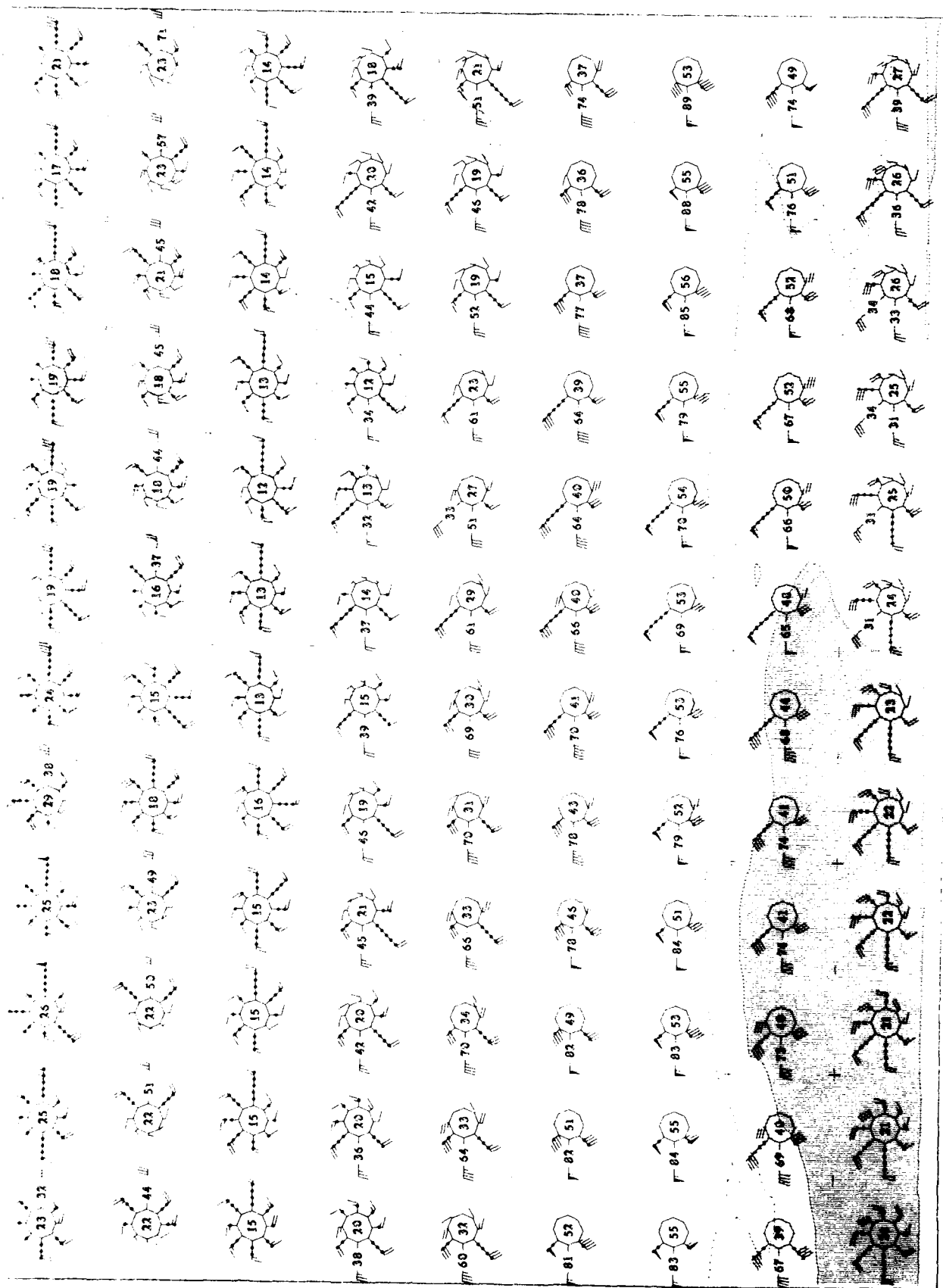
Agenda
50. 10. 1950

Page 20 of 20
 2000-2001
 2000-2001

Page 20 of 20
 2000-2001
 2000-2001

Page 20 of 20
 2000-2001
 2000-2001

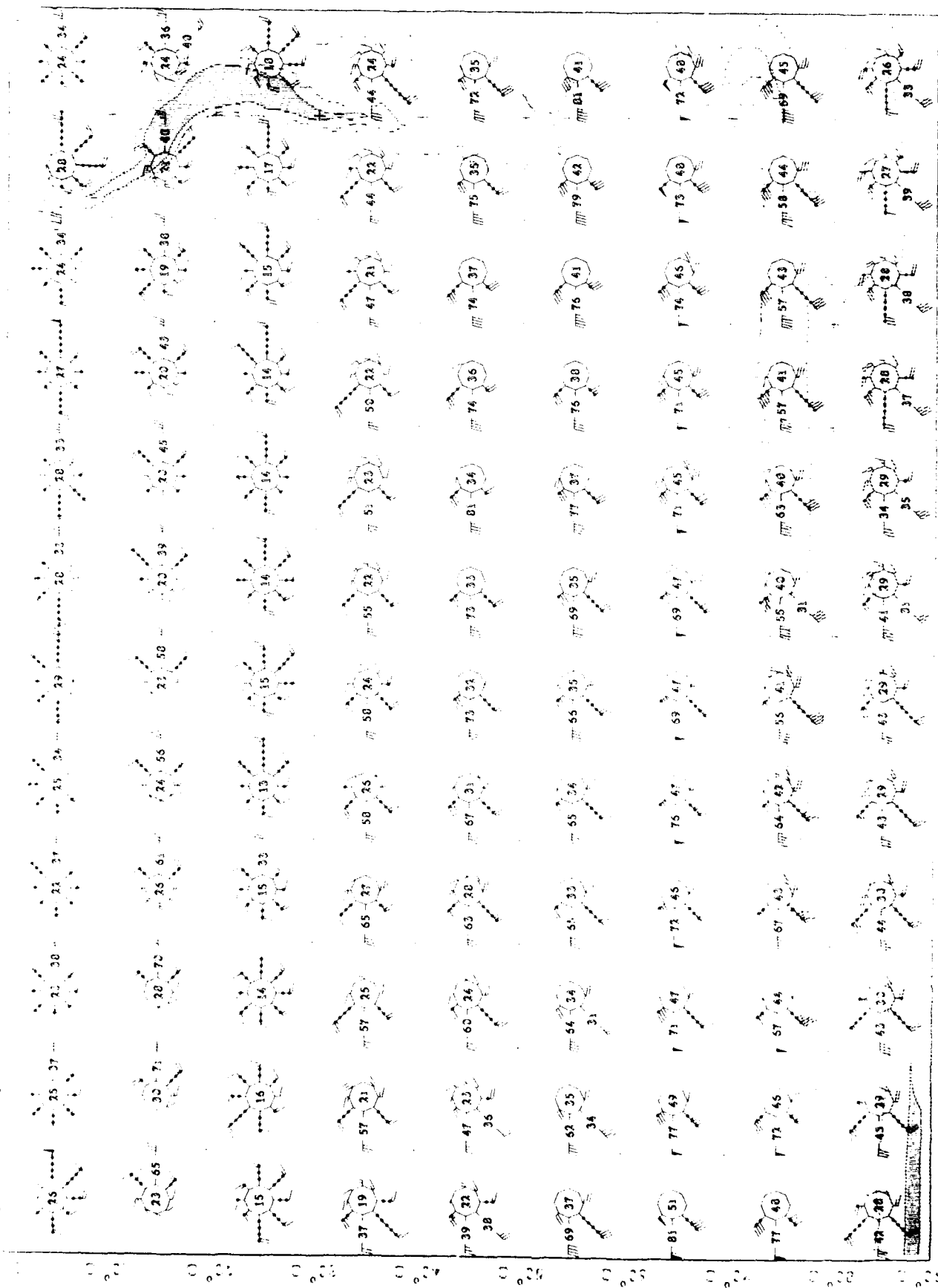




Upper Air Climatology
Northern Hemisphere

1960-1961
1960-1961

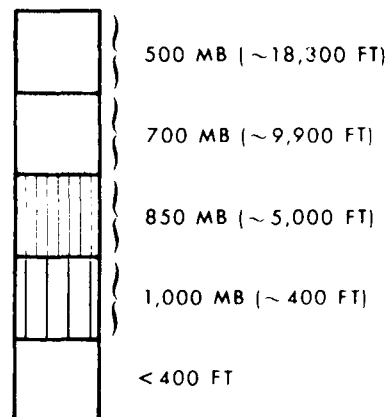
April
30 Mib



JET STREAM
(10 LEVELS, 500 TO 30 MB)

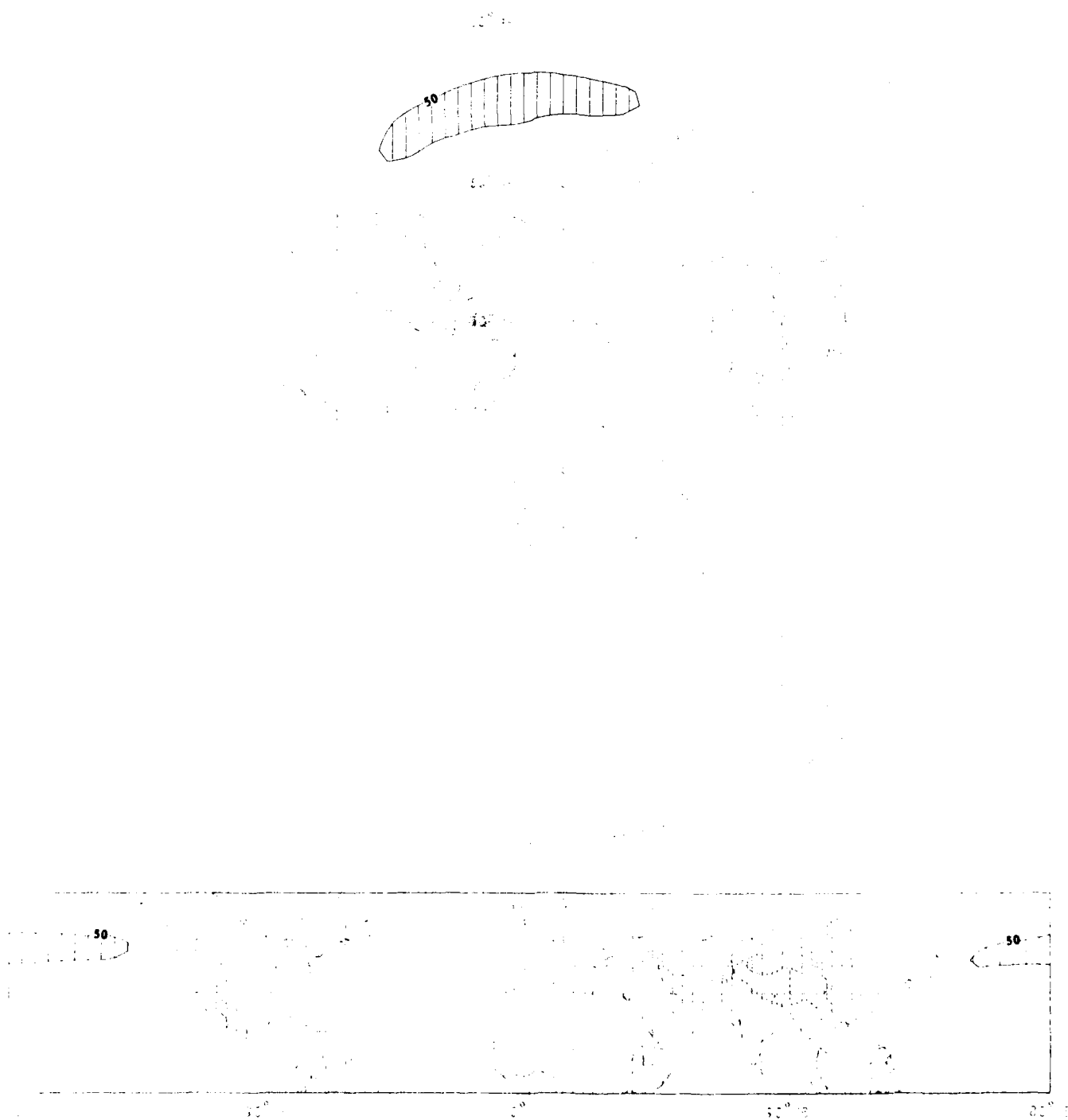
- Contours of mean scalar wind speed in knots
- Minimum mean scalar speed: 50 knots
- Contour interval of mean scalar speed: 25 knots

ELEVATION SCALE



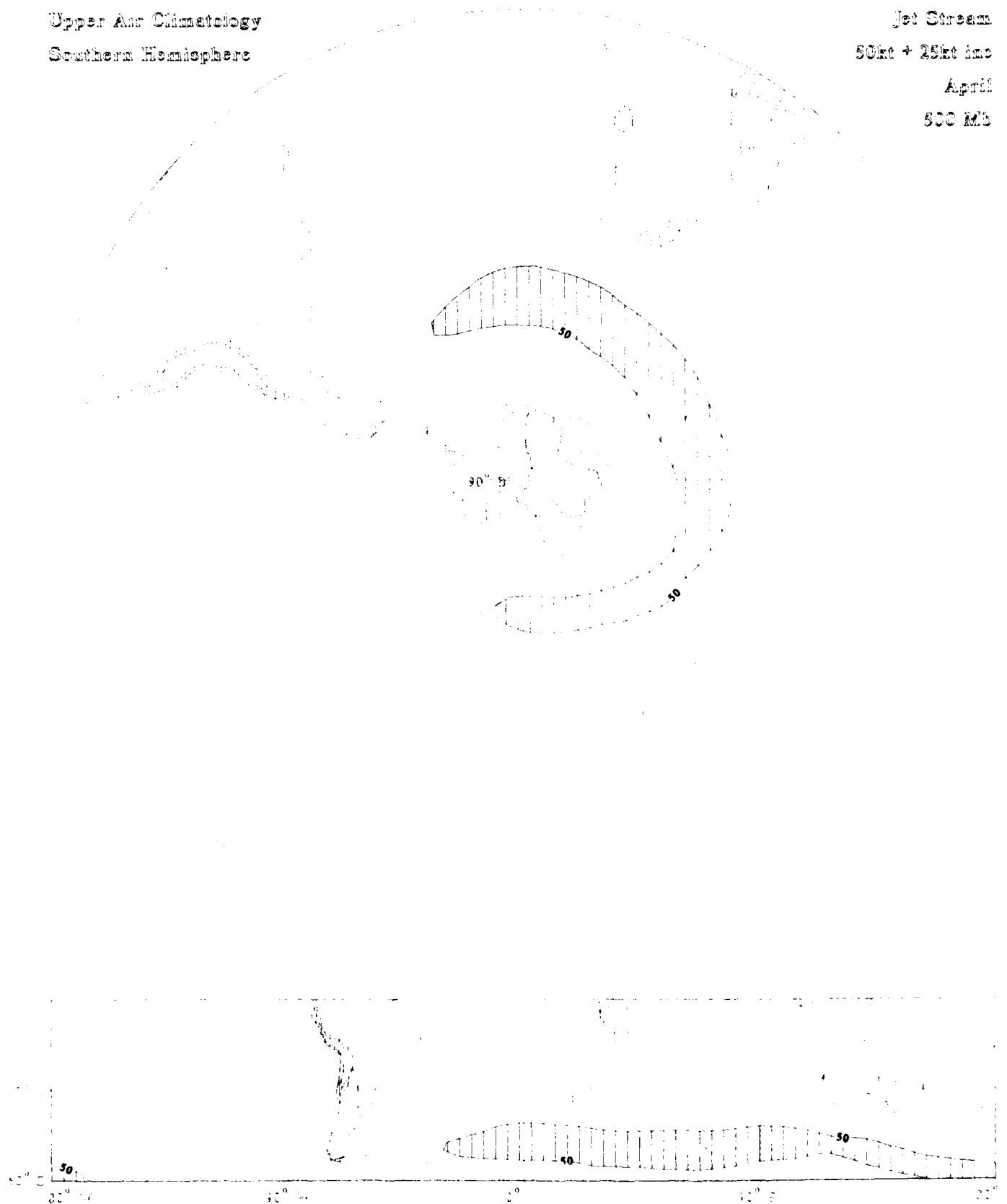
Jet Stream
50kt + 25kt inc
April
500 MB

Upper Air Climatology
Northern Hemisphere



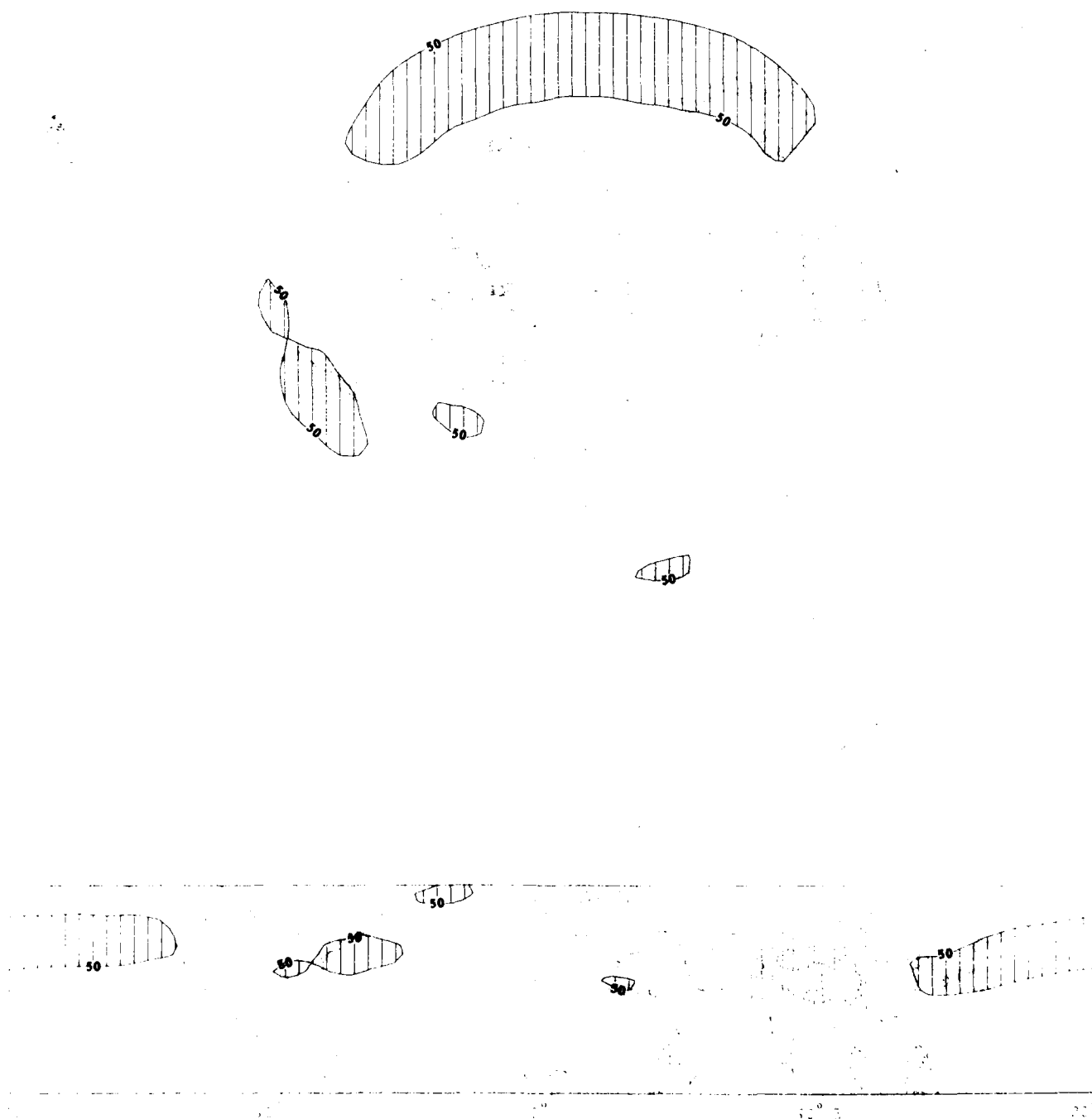
Upper Air Climatology
Southern Hemisphere

Jet Stream
50kt + 25kt inc
April
500 MB



Jet Stream
50kt + 25kt inc
April
400 Mb

Upper Air Climatology
Northern Hemisphere



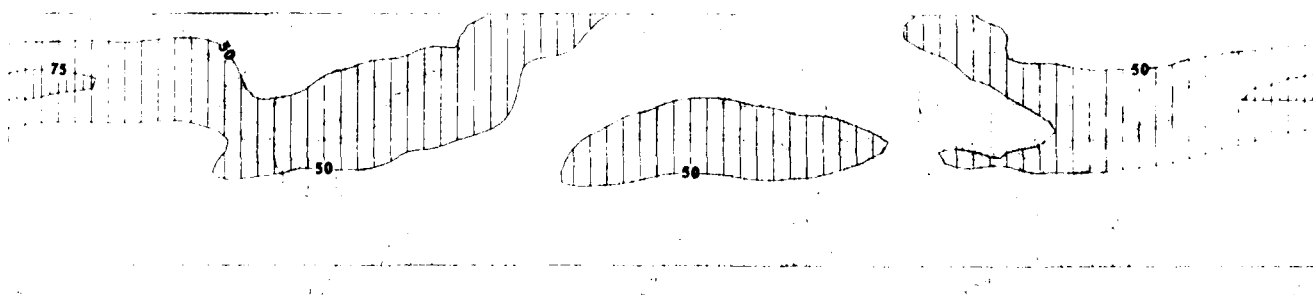
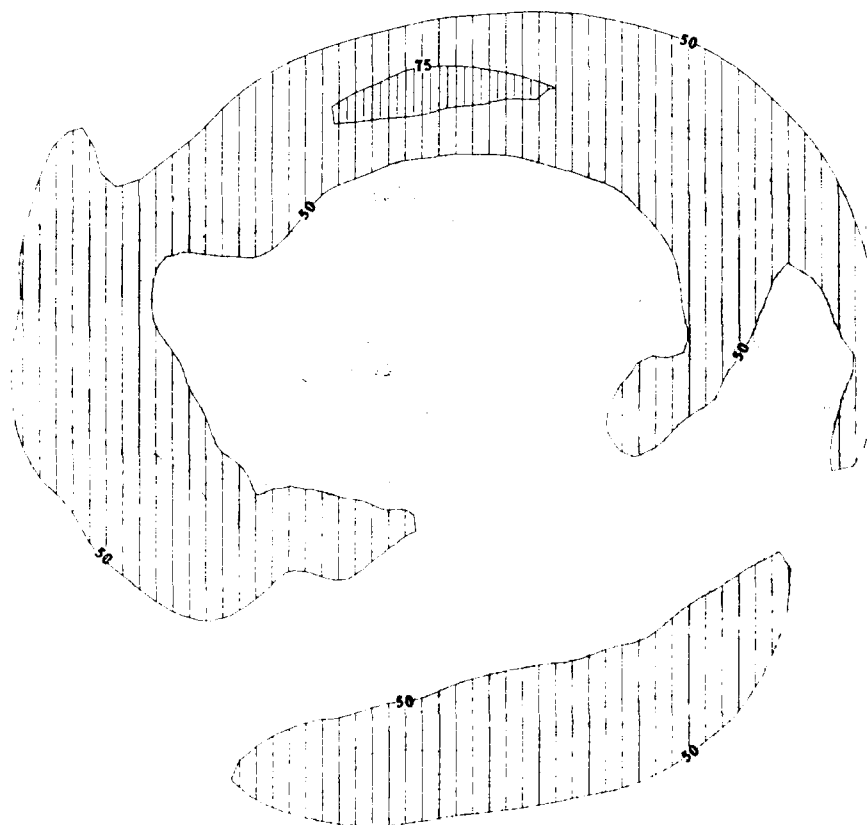
Upper Air Climatology
Southern Hemisphere

Jet Stream
50kt + 25kt inc
April
400 Mb



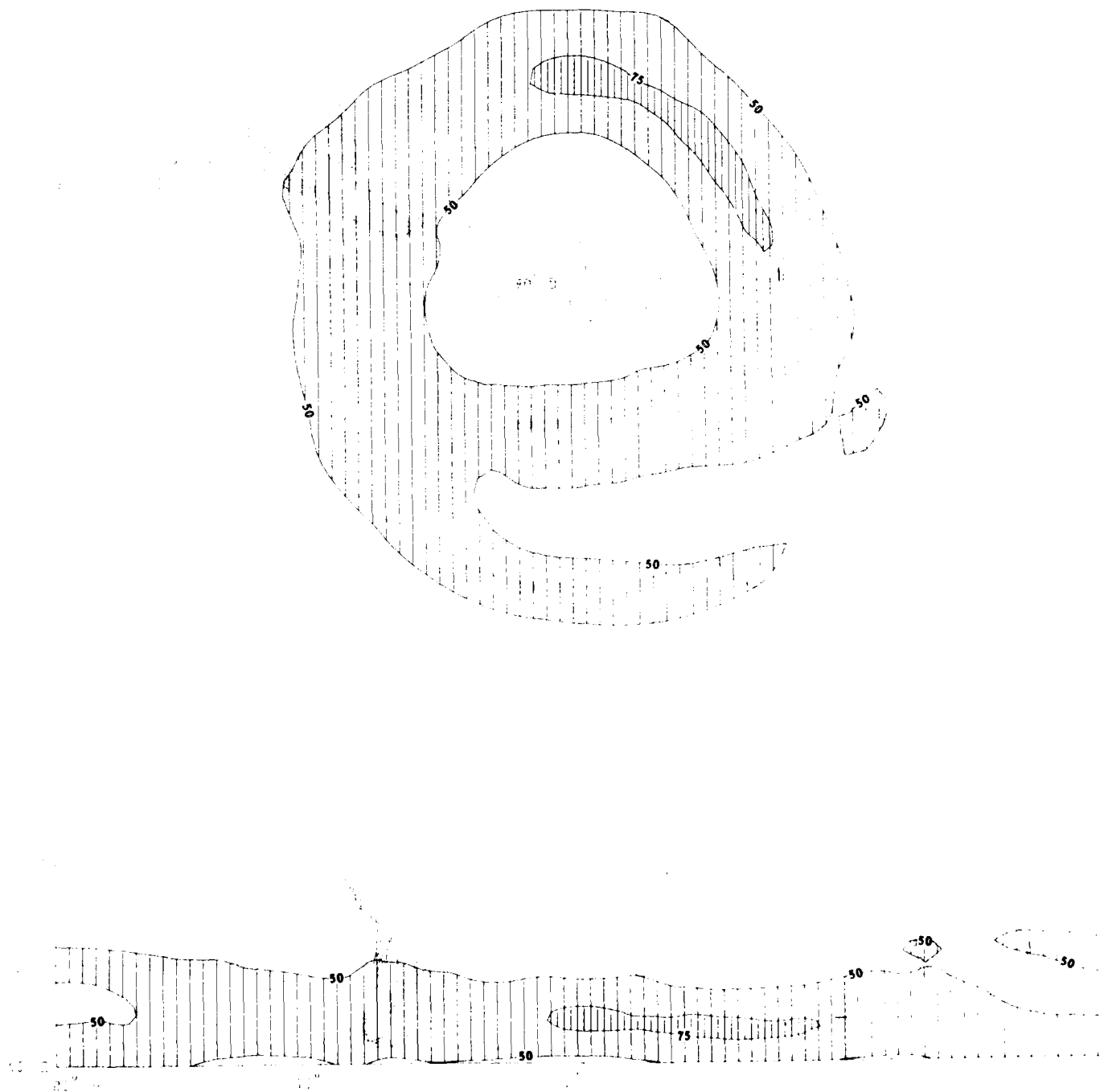
Jet Stream
50kt + 25kt inc
April
300 Mb

Upper Air Climatology
Northern Hemisphere



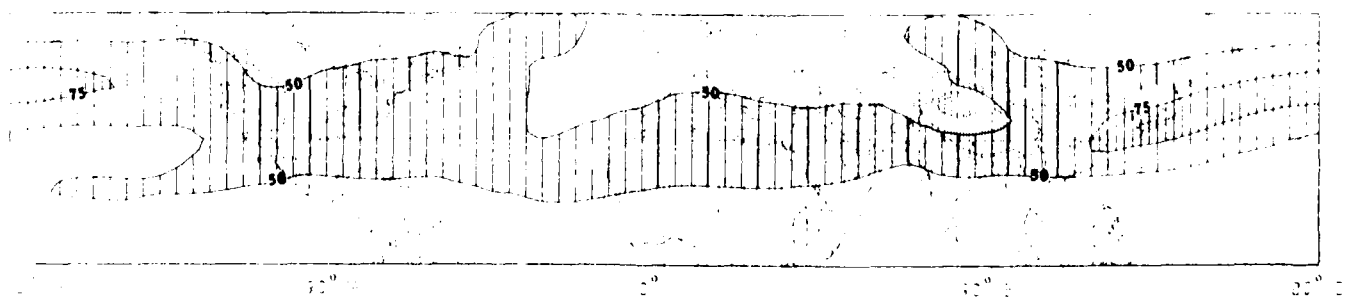
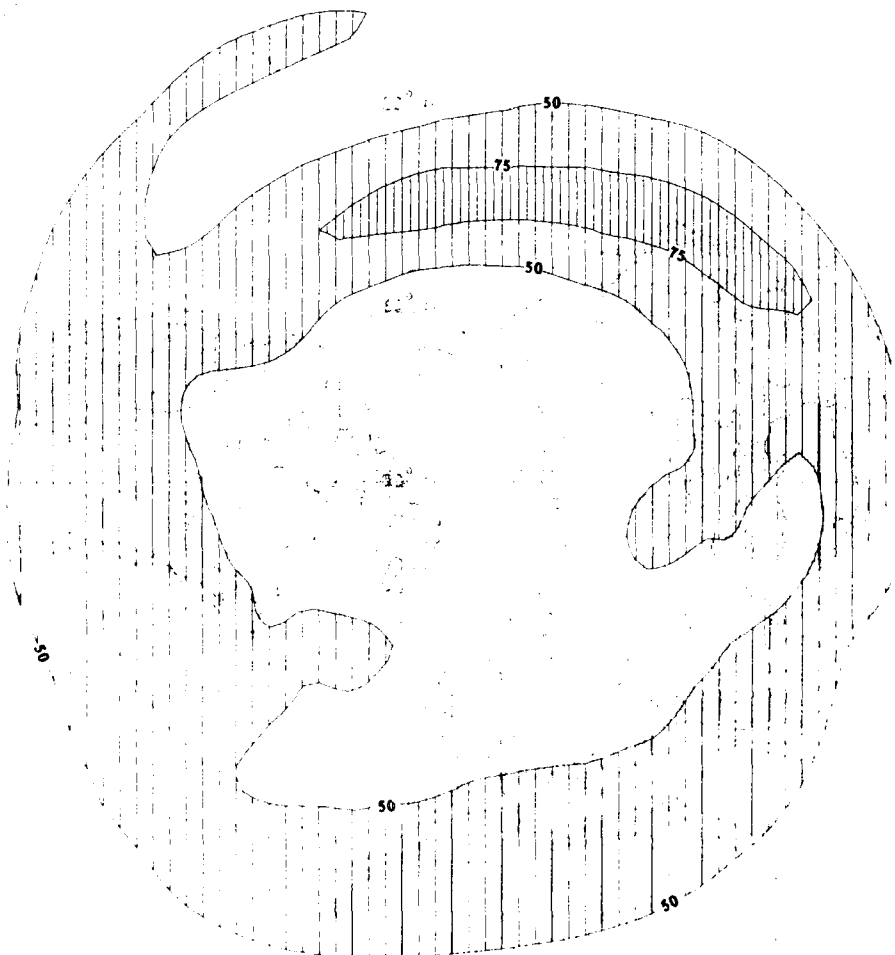
Upper Air Climatology
Southern Hemisphere

Jet Stream
50kt + 25kt inc
April
300 MB



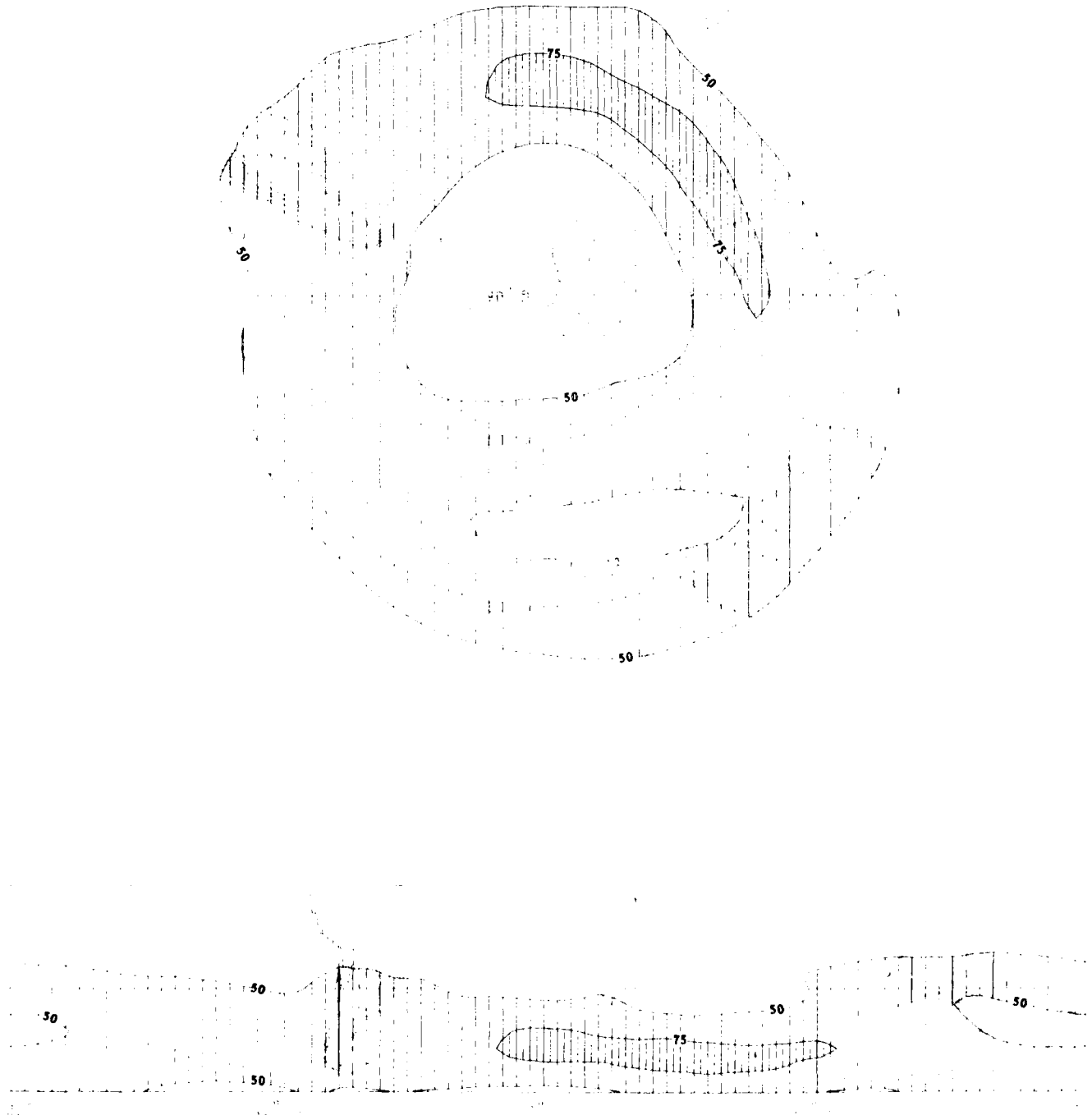
Jet Stream
50kt + 25kt inc
April
250 Mb

Upper Air Climatology
Northern Hemisphere



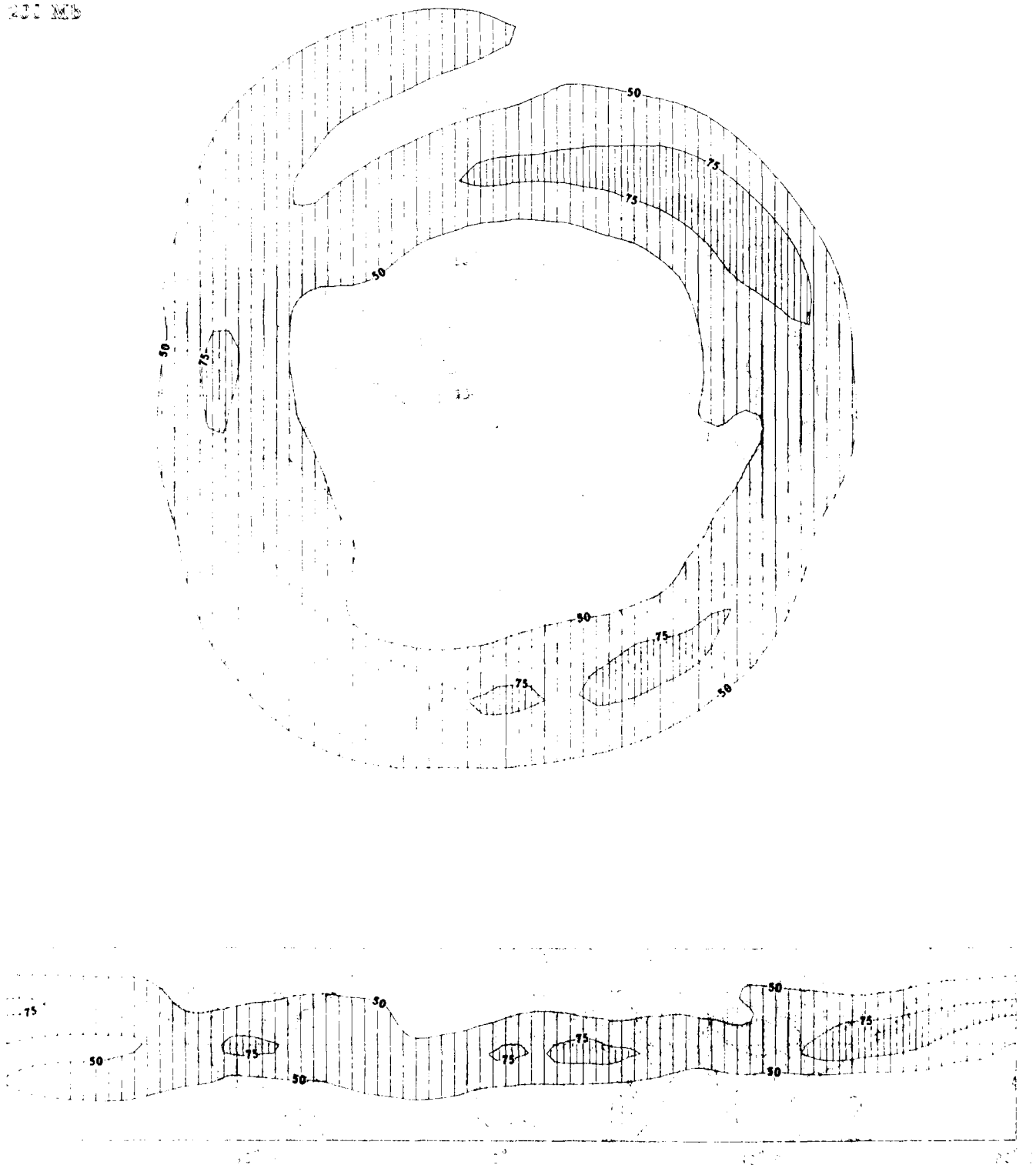
Upper Air Climatology
Southern Hemisphere

Jet Stream
50kt + 25kt inc
April
250 MB



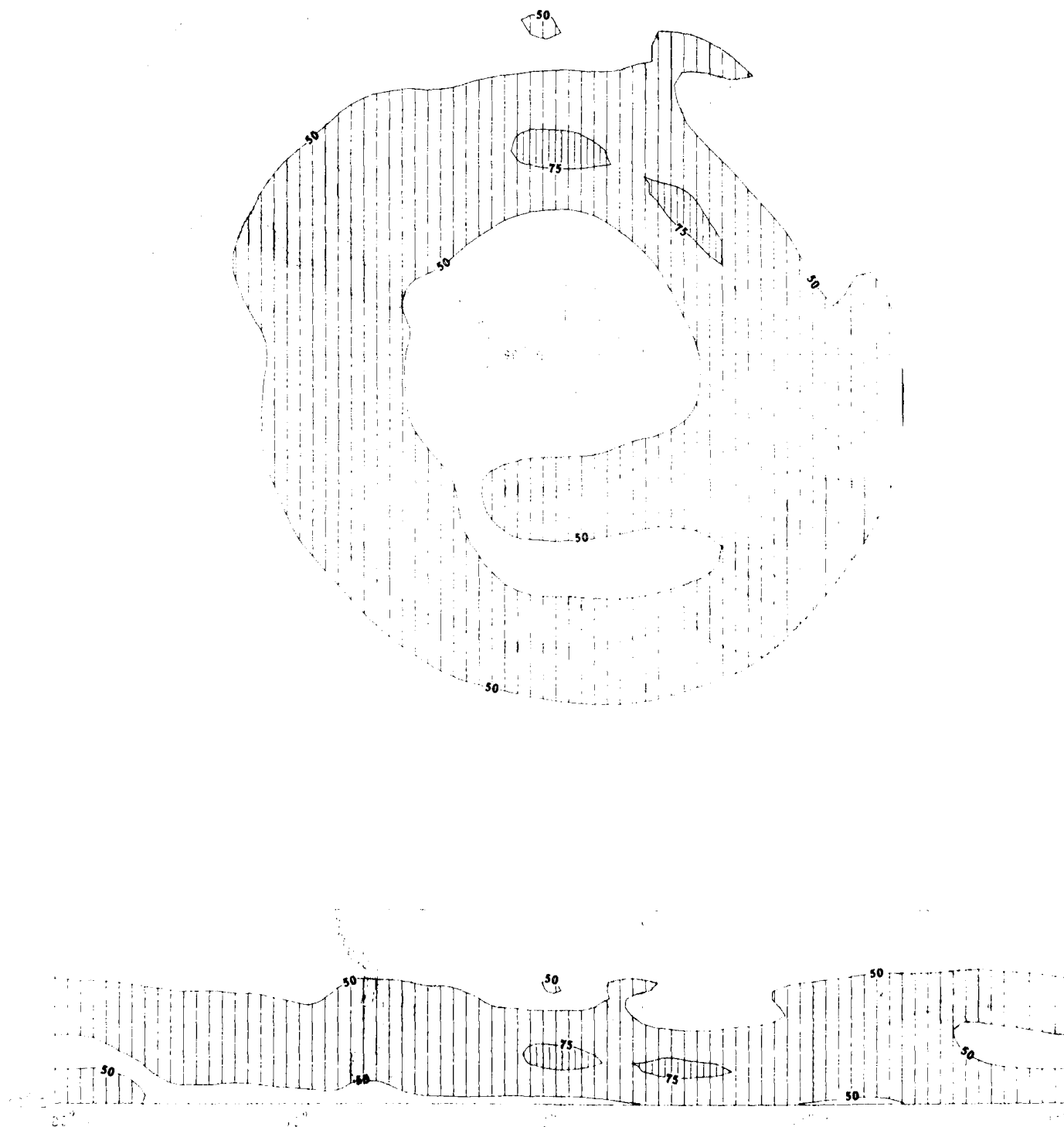
Jet Stream
50kt + 25kt inc
April
201 MB

Upper Air Climatology
Northern Hemisphere



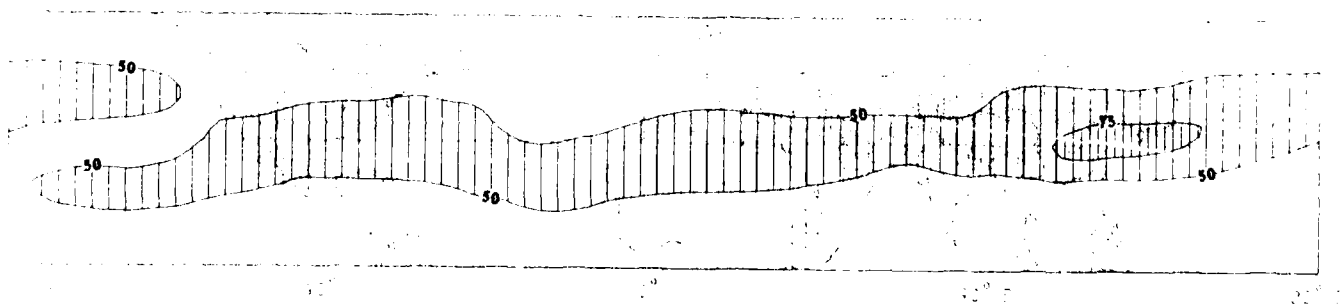
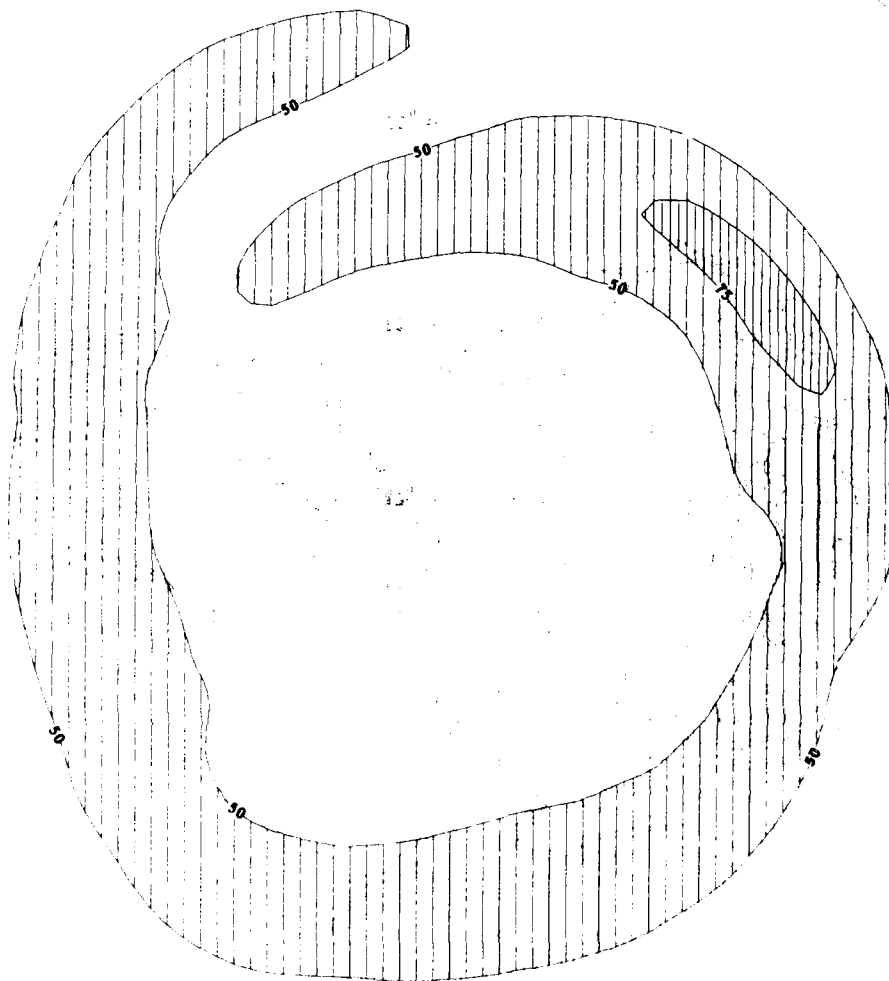
Upper Air Climatology
Southern Hemisphere

Jet Stream
50kt + 25kt inc
April
200 MB



Jet Stream
50kt + 25kt inc
April
150 Mb

Upper Air Climatology
Northern Hemisphere



Dr. [illegible]

Figure 1. [illegible]

1960 - 1961

1960 - 1961

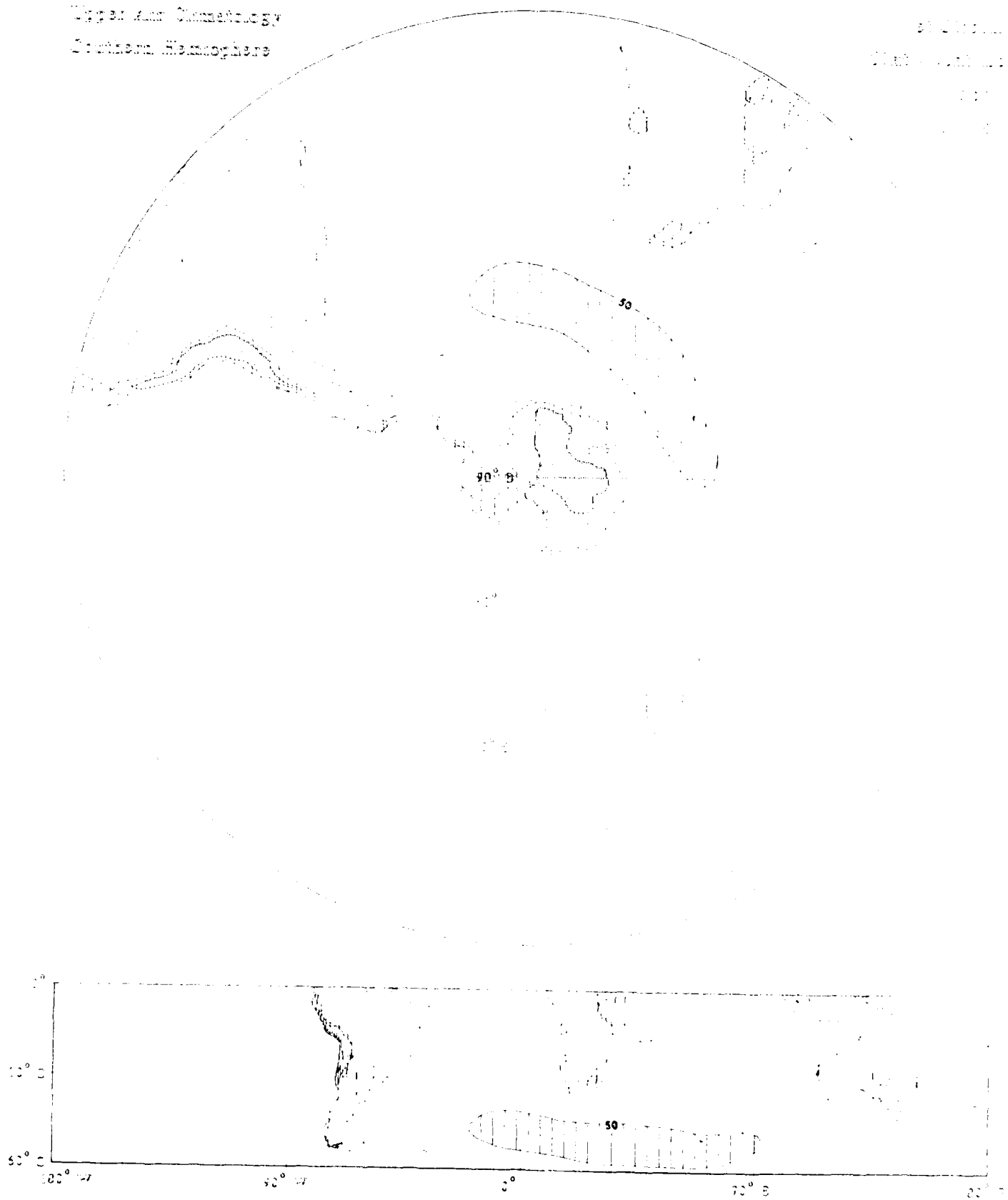
1961

1961



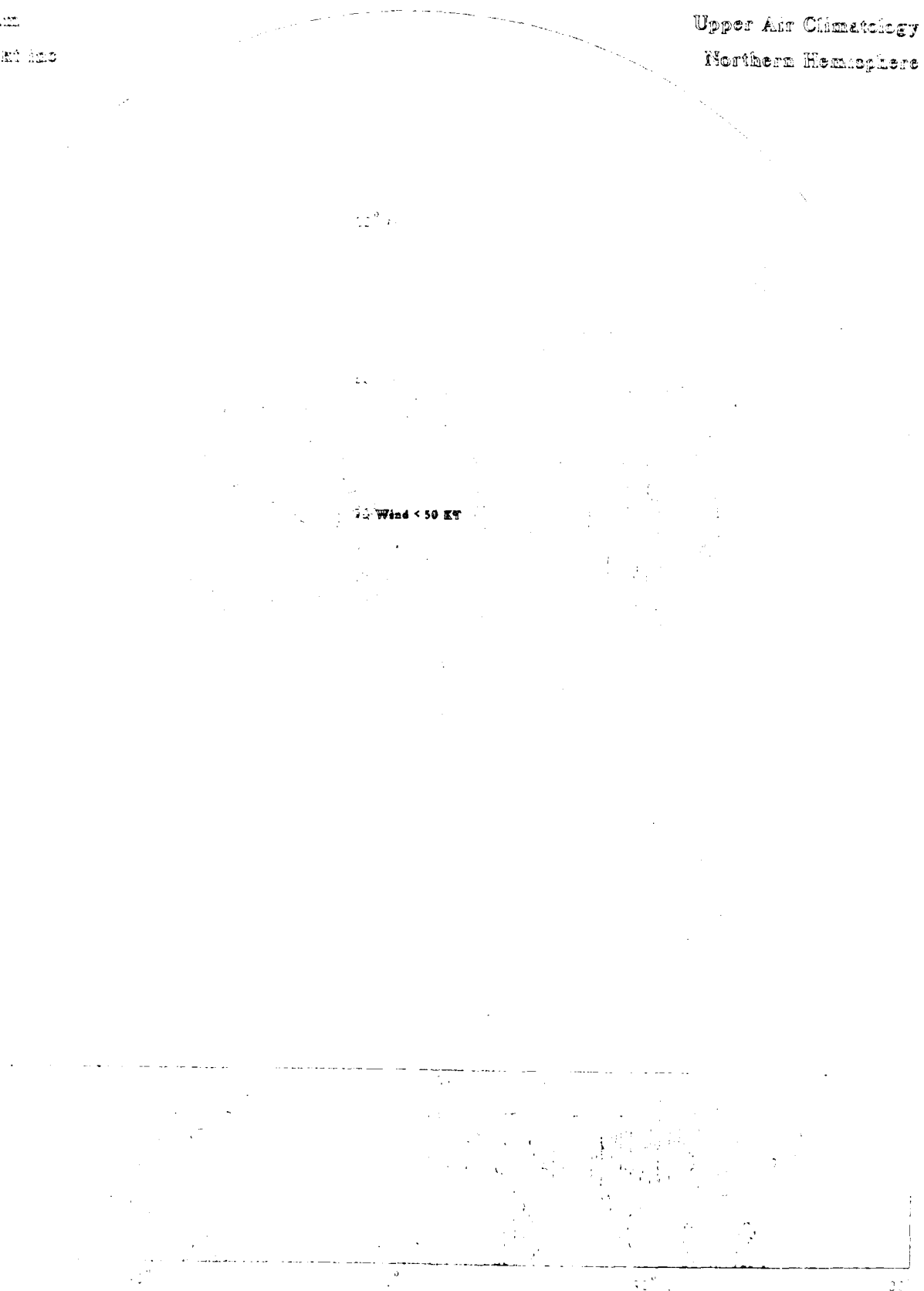
Upper Air Climatology
Southern Hemisphere

500 mb
1000 mb
1500 mb
2000 mb
2500 mb
3000 mb
3500 mb
4000 mb
4500 mb
5000 mb
5500 mb
6000 mb
6500 mb
7000 mb
7500 mb
8000 mb
8500 mb
9000 mb
9500 mb
10000 mb



Jet Stream
50kt + 50kt line
April
1950

Upper Air Climatology
Northern Hemisphere



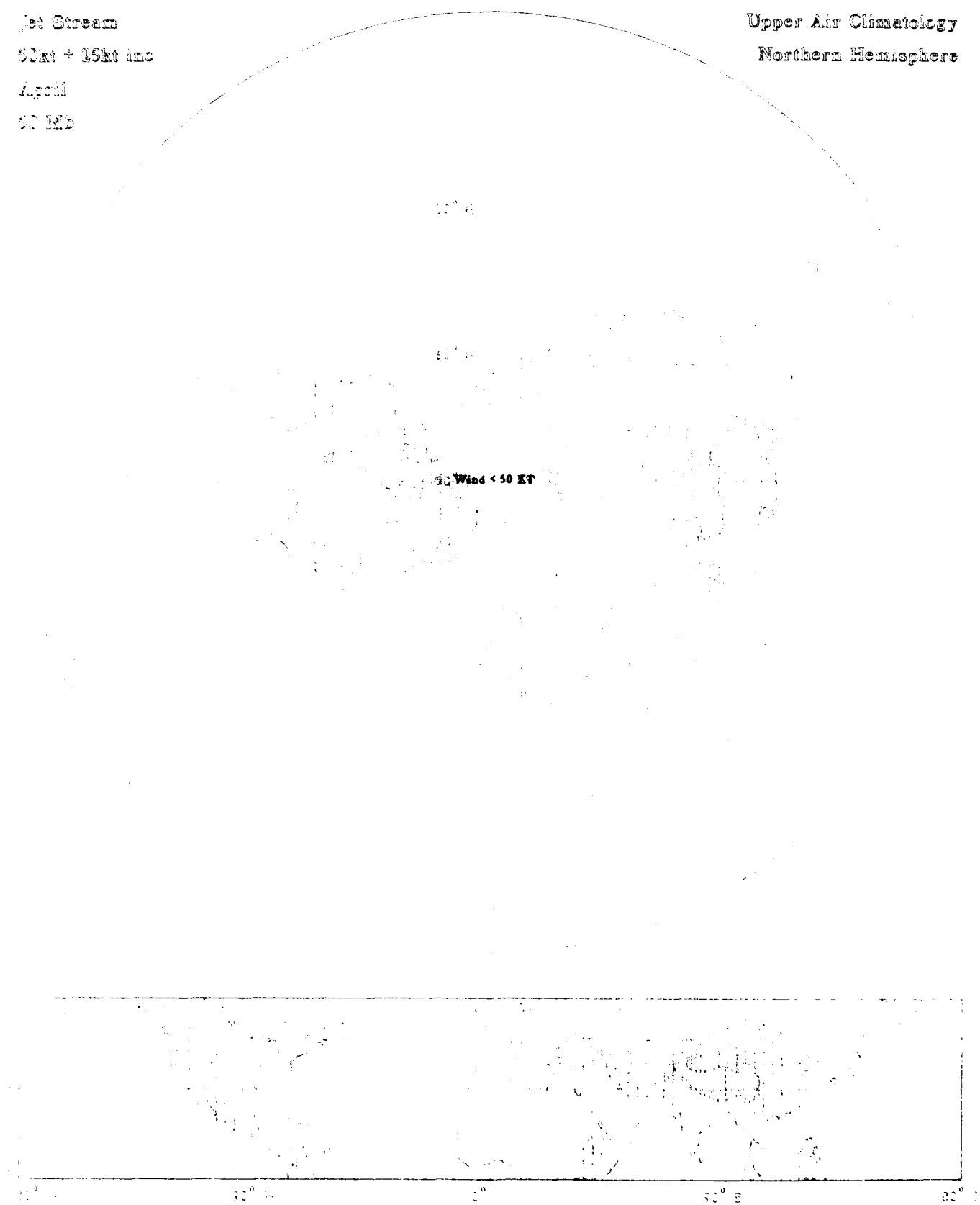
Upper Air Climatology
Southern Hemisphere

Jet Stream
50mb + 25mb and
Area
1950-1951



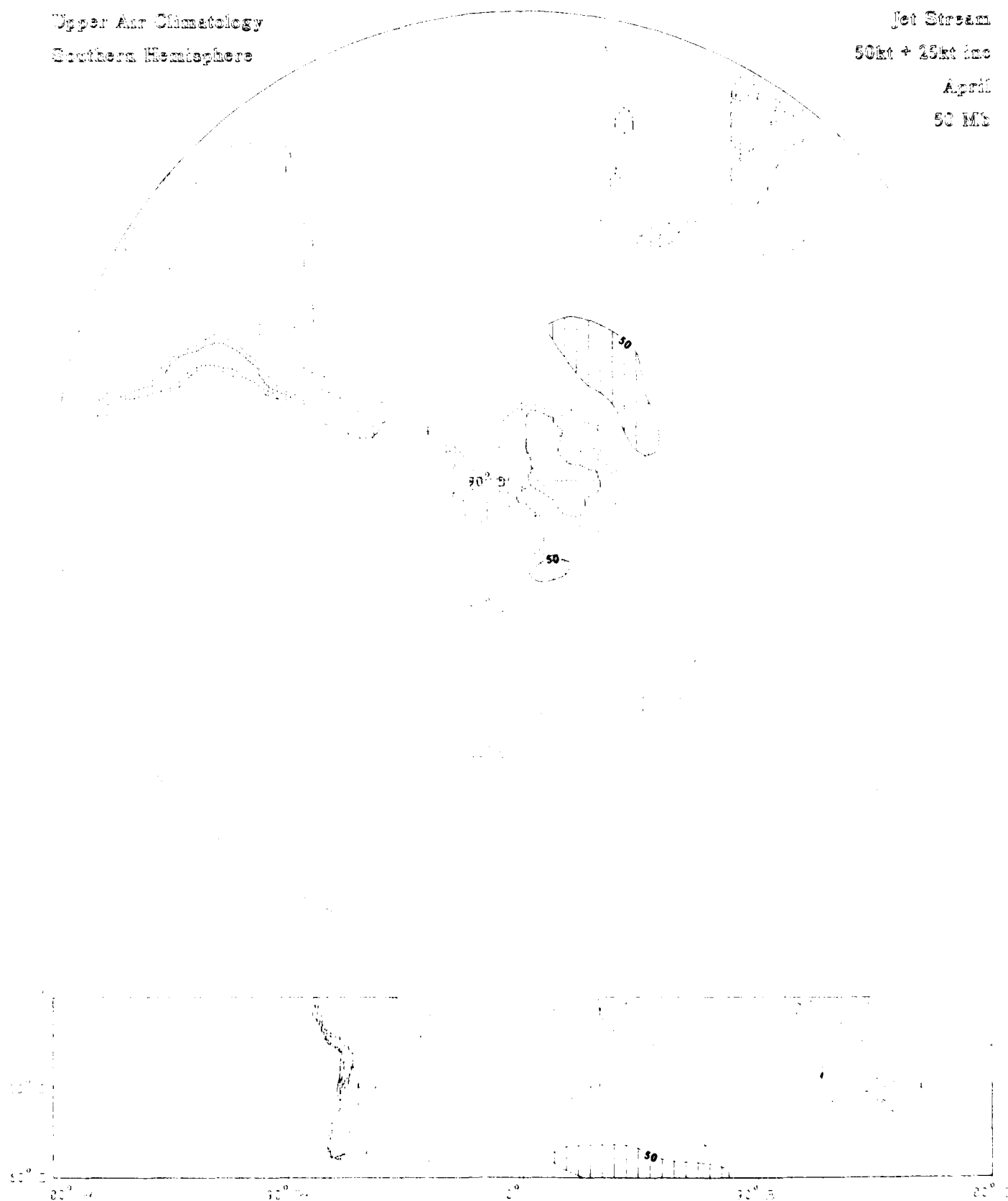
Jet Stream
50kt + 25kt inc
April
50 MB

Upper Air Climatology
Northern Hemisphere



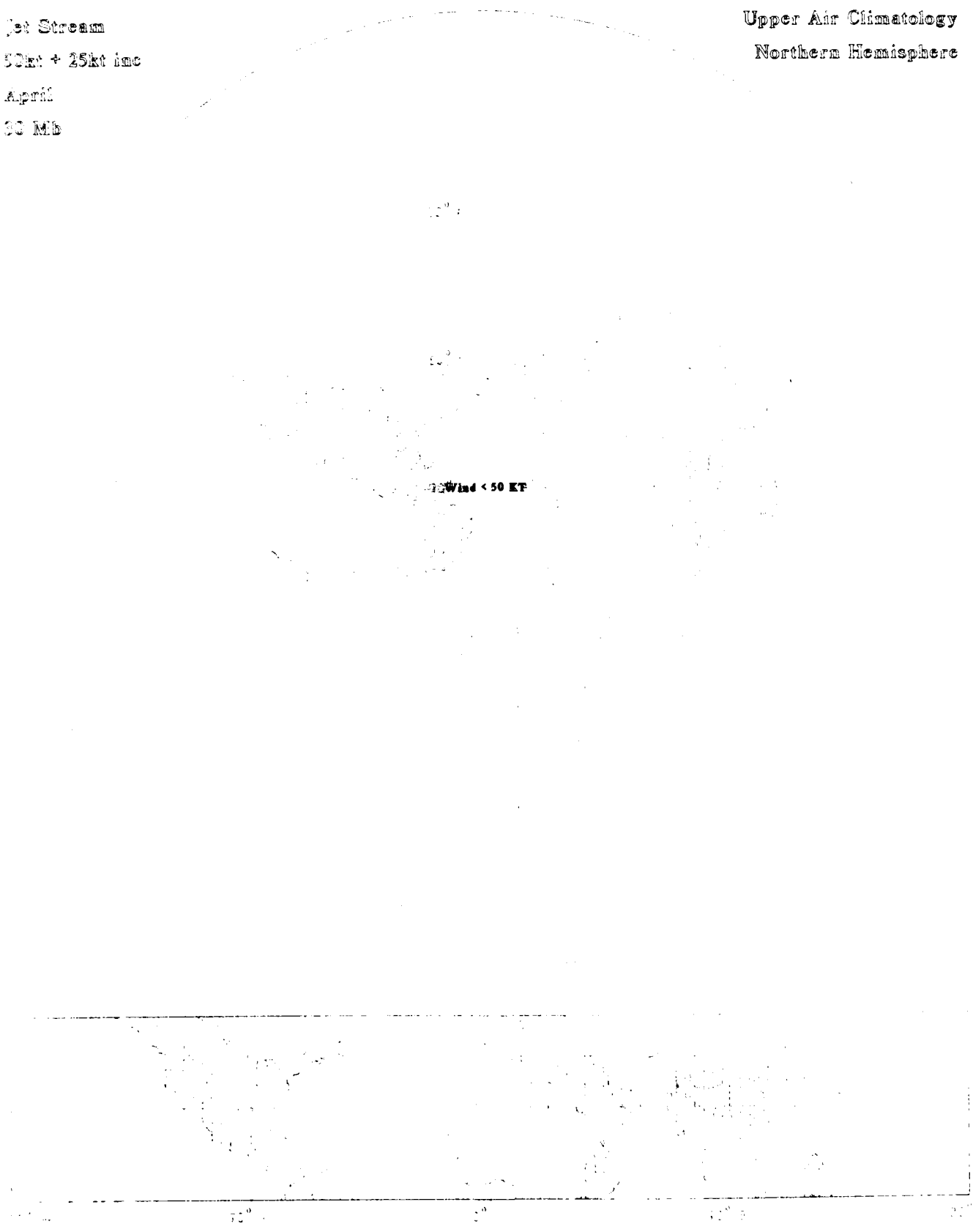
Upper Air Climatology
Southern Hemisphere

Jet Stream
50kt + 25kt inc
April
50 Mb



Jet Stream
50kt + 25kt inc
April
30 Mb

Upper Air Climatology
Northern Hemisphere



Upper Air Climatology
Southern Hemisphere

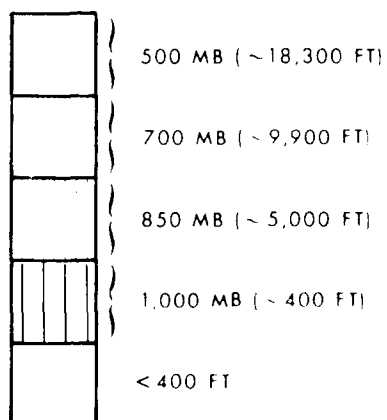
Jet Stream
51st + 10th Dec
April
11 121



TEMPERATURE
(13 LEVELS, 1000 TO 30 MB)

- Contours of mean temperature (solid and dashed lines) in °C; solids labeled, dashed intermediates unlabeled
- Temperature labeled interval: 5°C
- Contours of standard deviation of temperature (dotted lines) in °C
- Standard deviation of temperature labeled interval: 2.5°C
- Contours blanked for geographic areas with elevations exceeding specified geopotential heights

ELEVATION SCALE



Mean Temperature (°C)

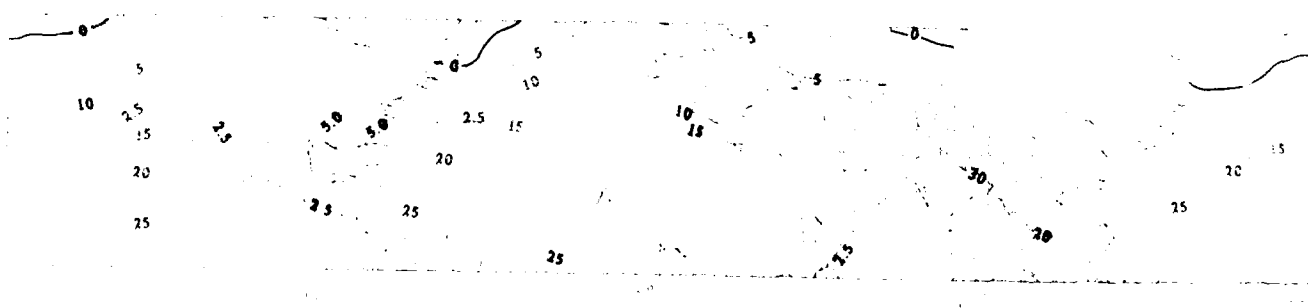
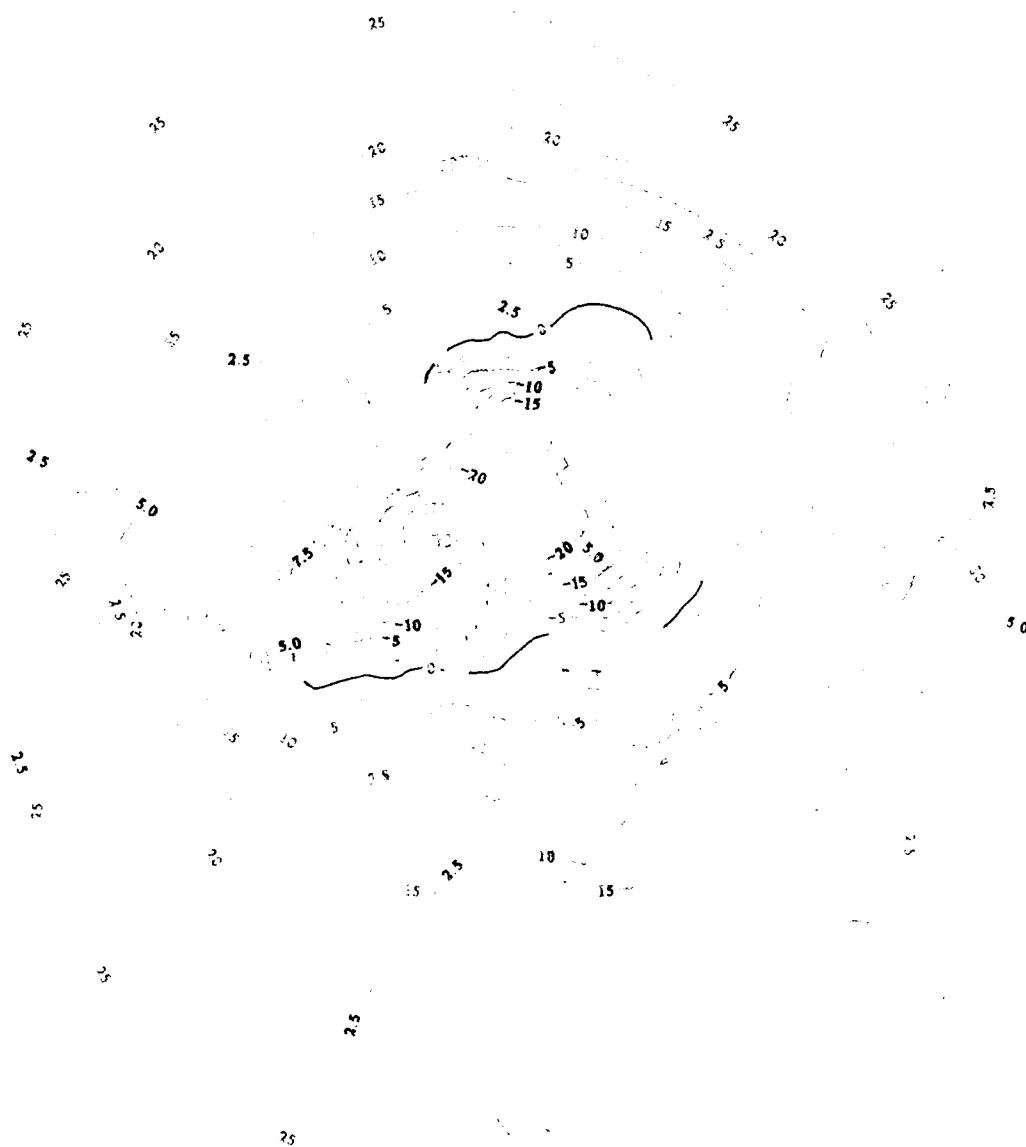
2000-1990 (1990)

1990

1990

Top 20 and 2000

1990-1990



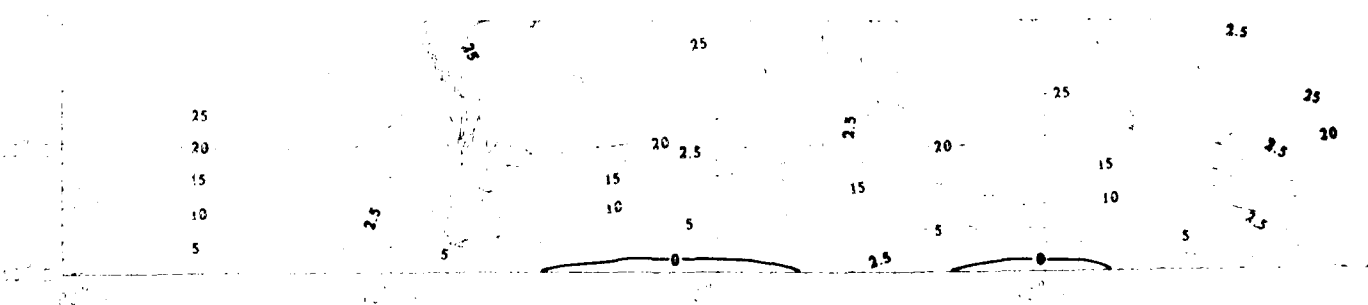
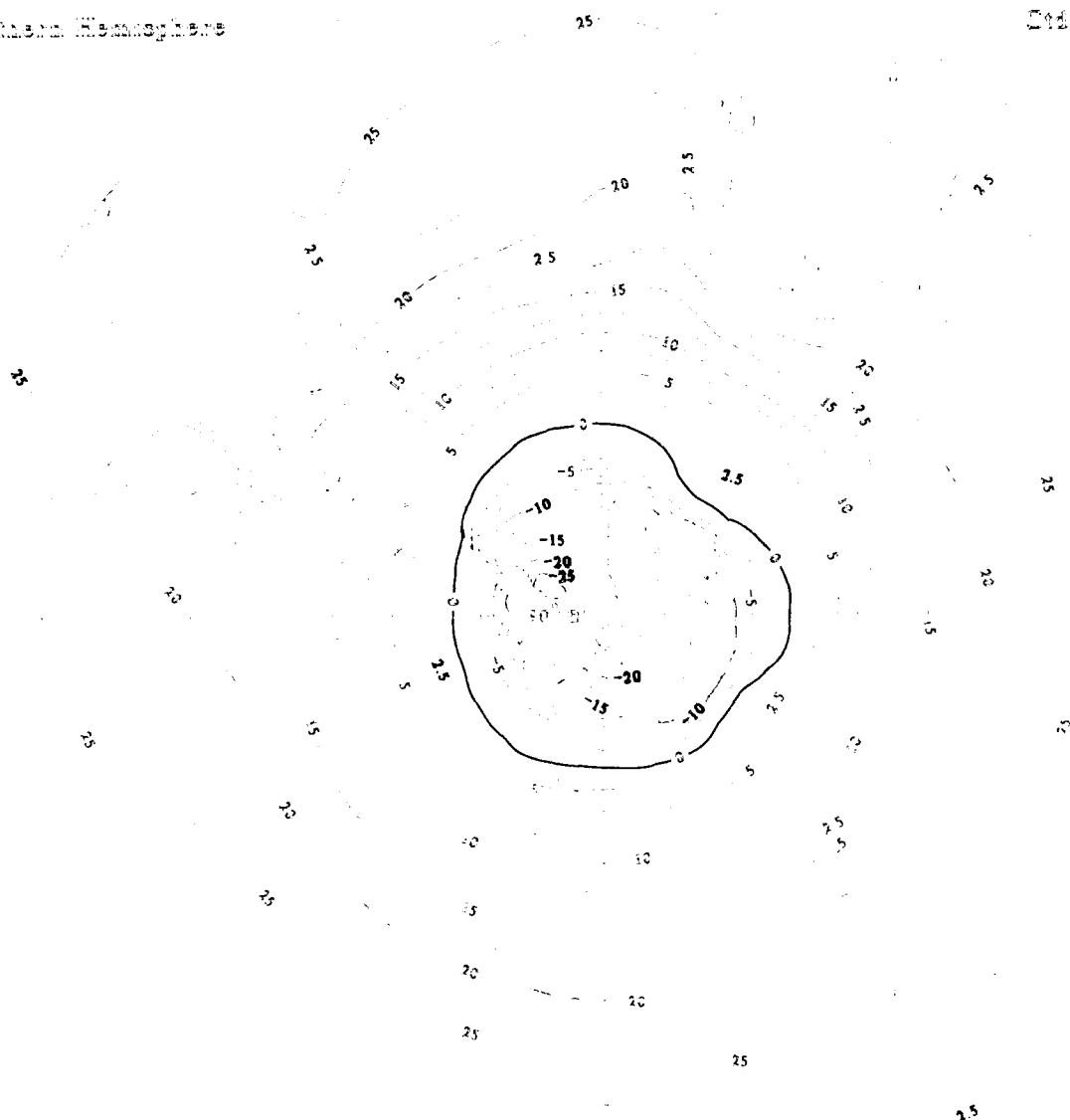
Upper Air Climatology
 Southern Hemisphere

Mean Temperature (°C)

Std Dev (Dotted)

April

1950-1959



Mean Temperature (°C)

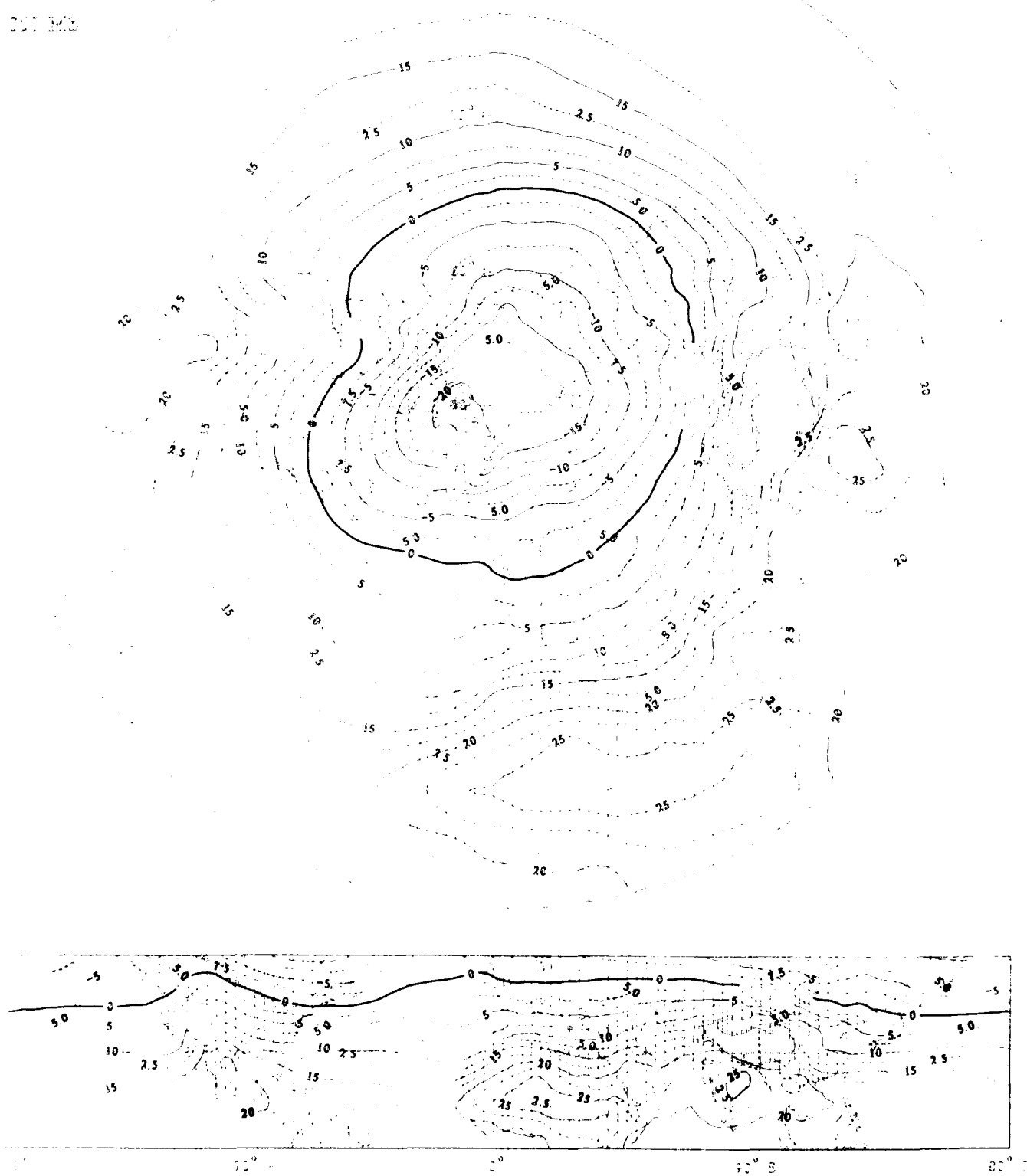
Sea Level (Capped)

April

000 MB

Upper Air Climatology

Northern Hemisphere



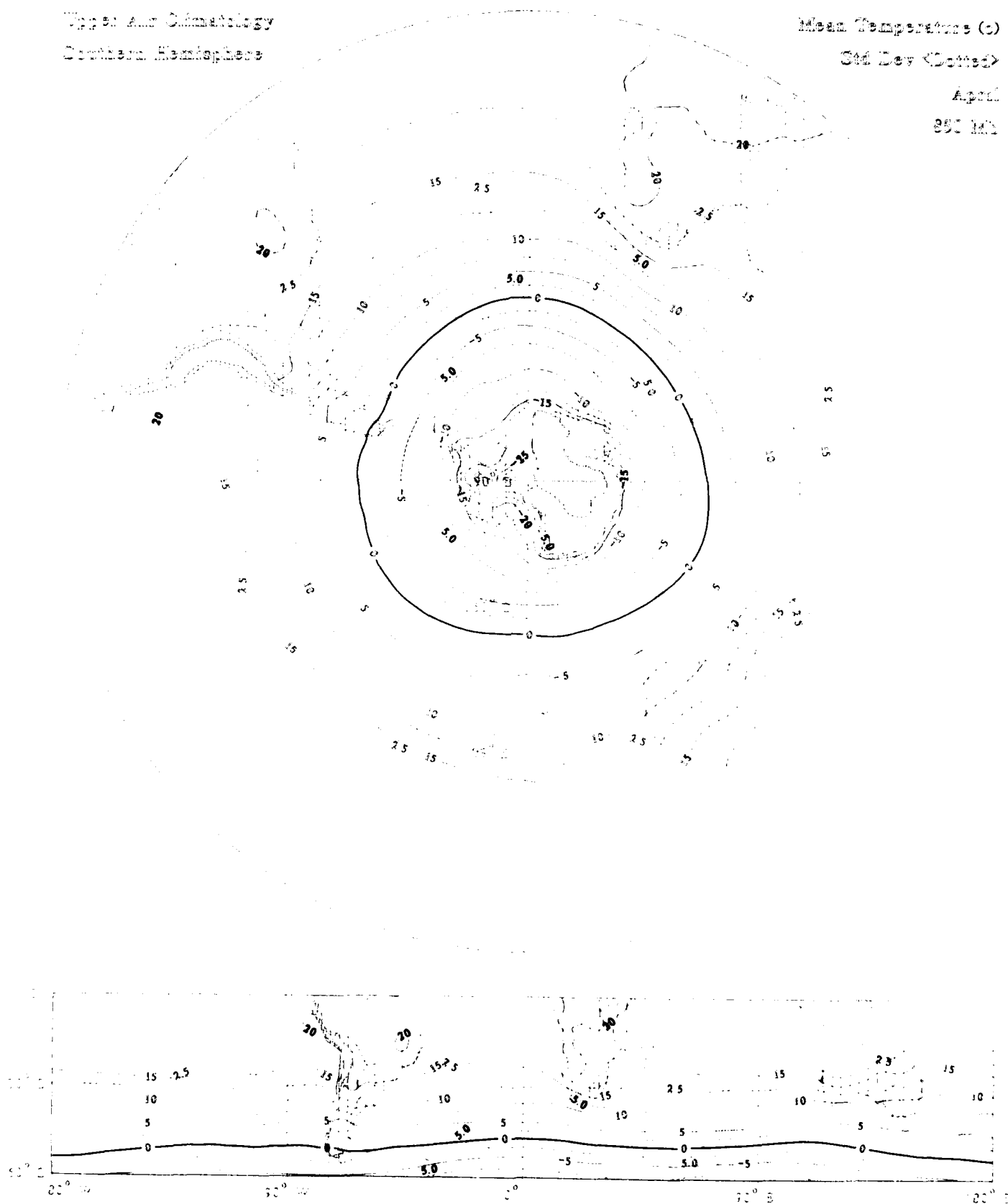
Upper Air Climatology
Southern Hemisphere

Mean Temperature (°C)

Std Dev (Cotted)

April

850 mb



Mean Temperature (°C)

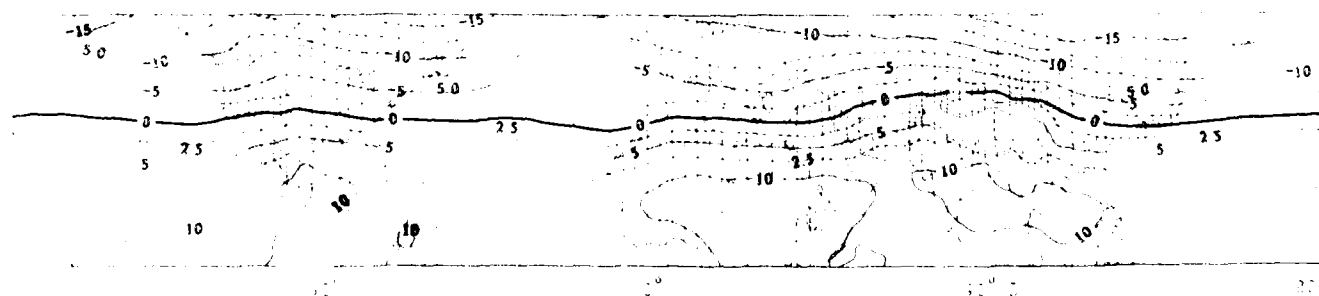
Std Dev (Dotted)

April

700 MB

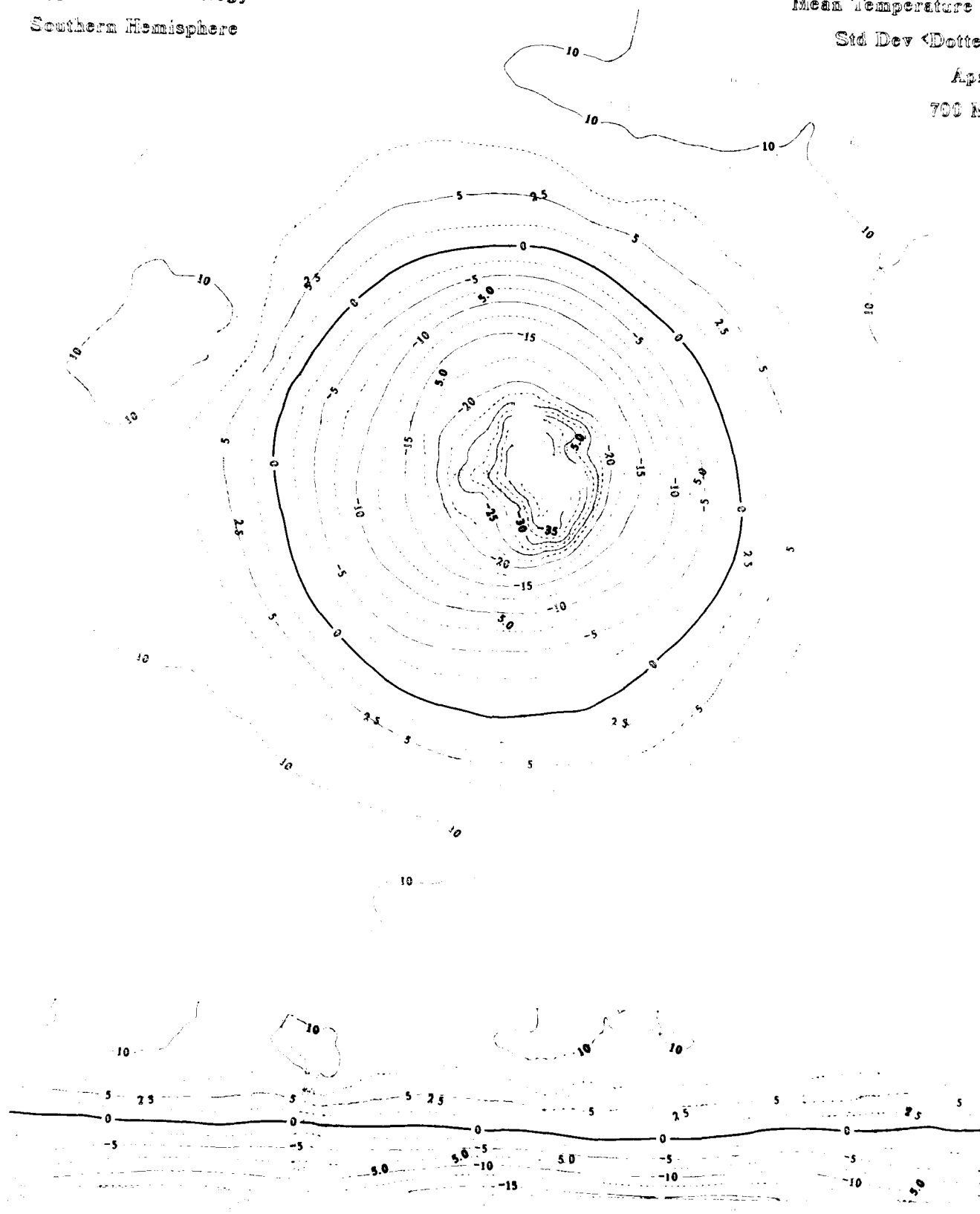
Upper Air Climatology

Northern Hemisphere



Upper Air Climatology
Southern Hemisphere

Mean Temperature (c)
Std Dev (Dotted)
April
700 MB



Mean Temperature (°C)

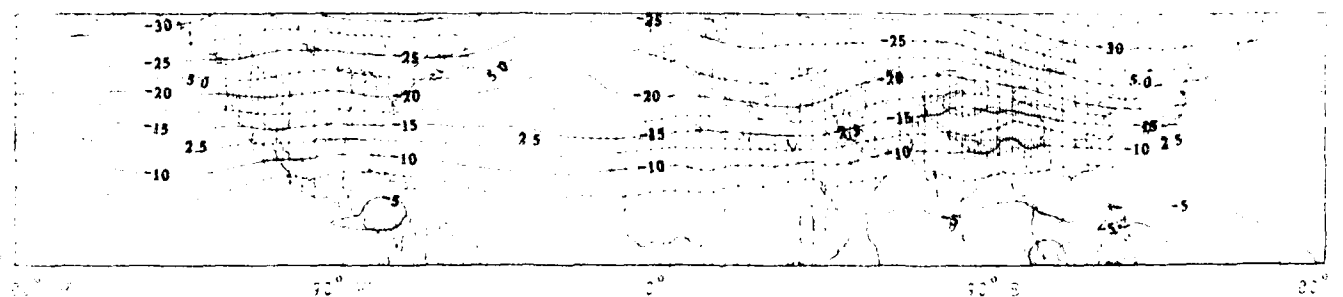
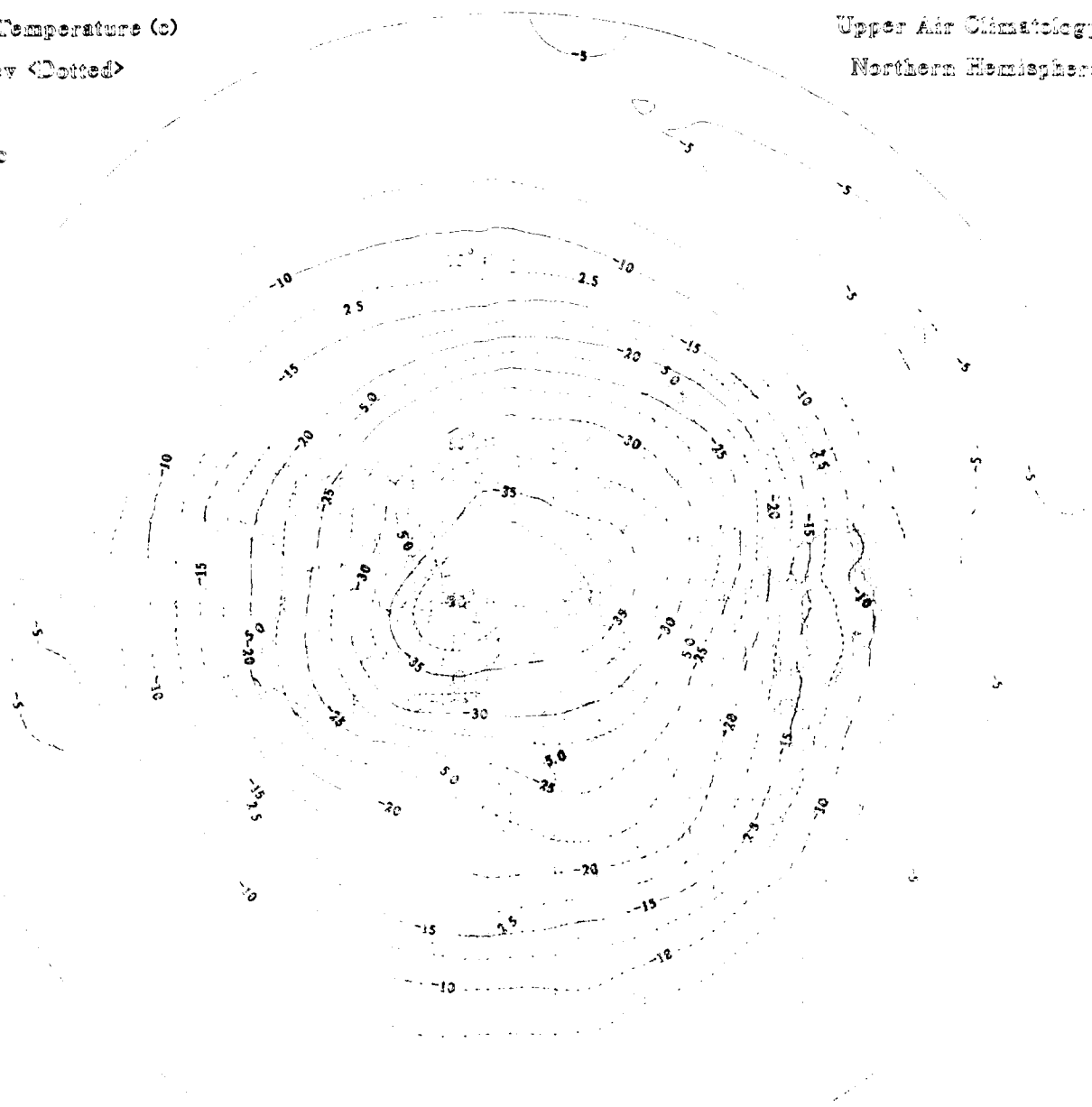
Std Dev (Dotted)

April

500 MB

Upper Air Climatology

Northern Hemisphere



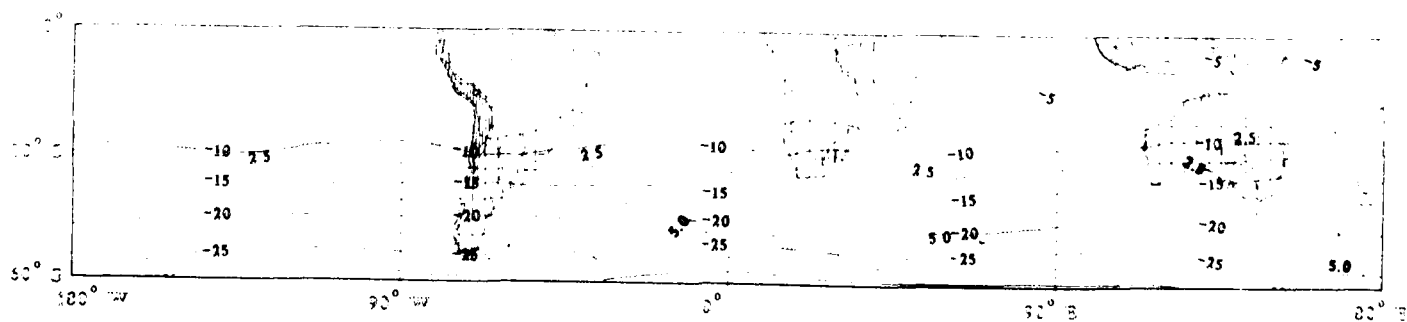
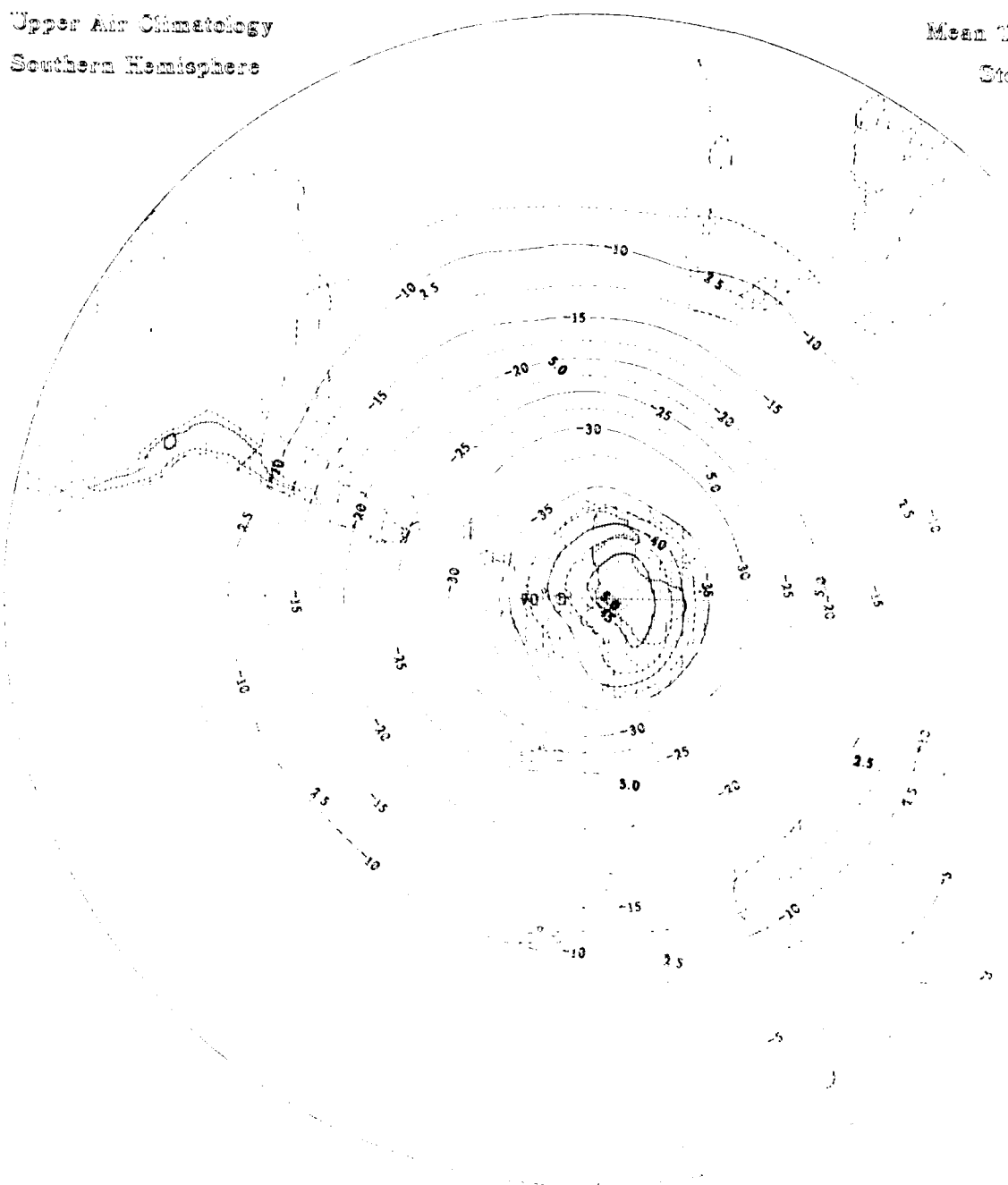
Upper Air Climatology
Southern Hemisphere

Mean Temperature (°C)

Std Dev (°C)

April

0000Z



Mean Temperature (°C)

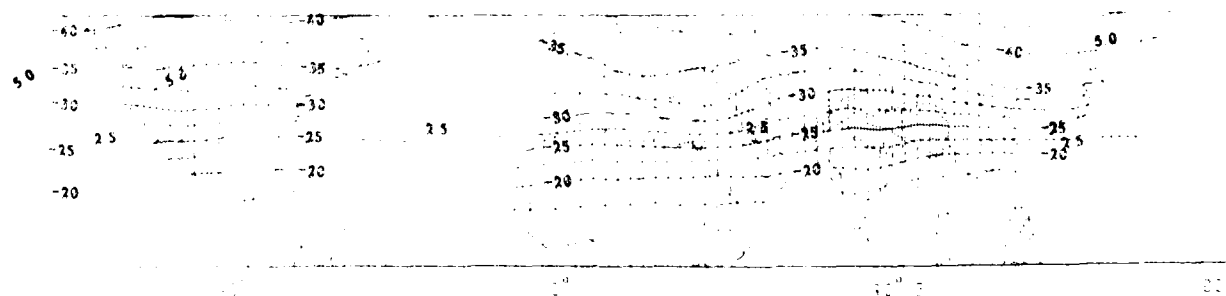
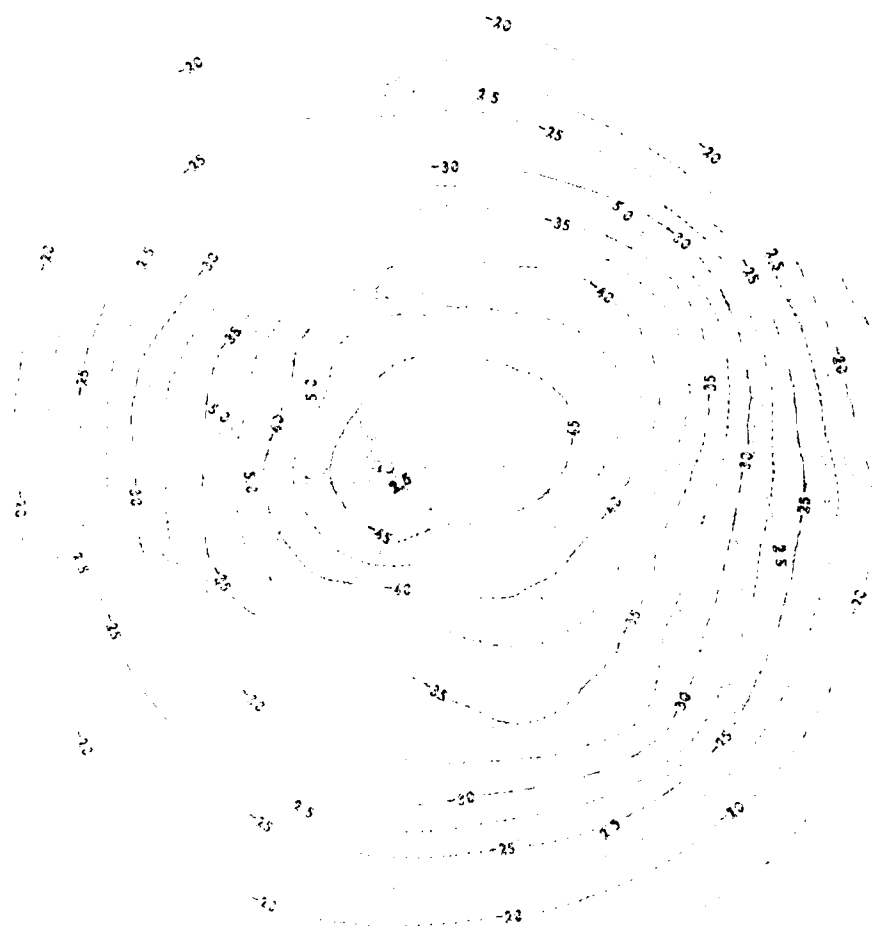
Sea Level (°C)

April

400 hPa

Upper Air Climatology

Northern Hemisphere



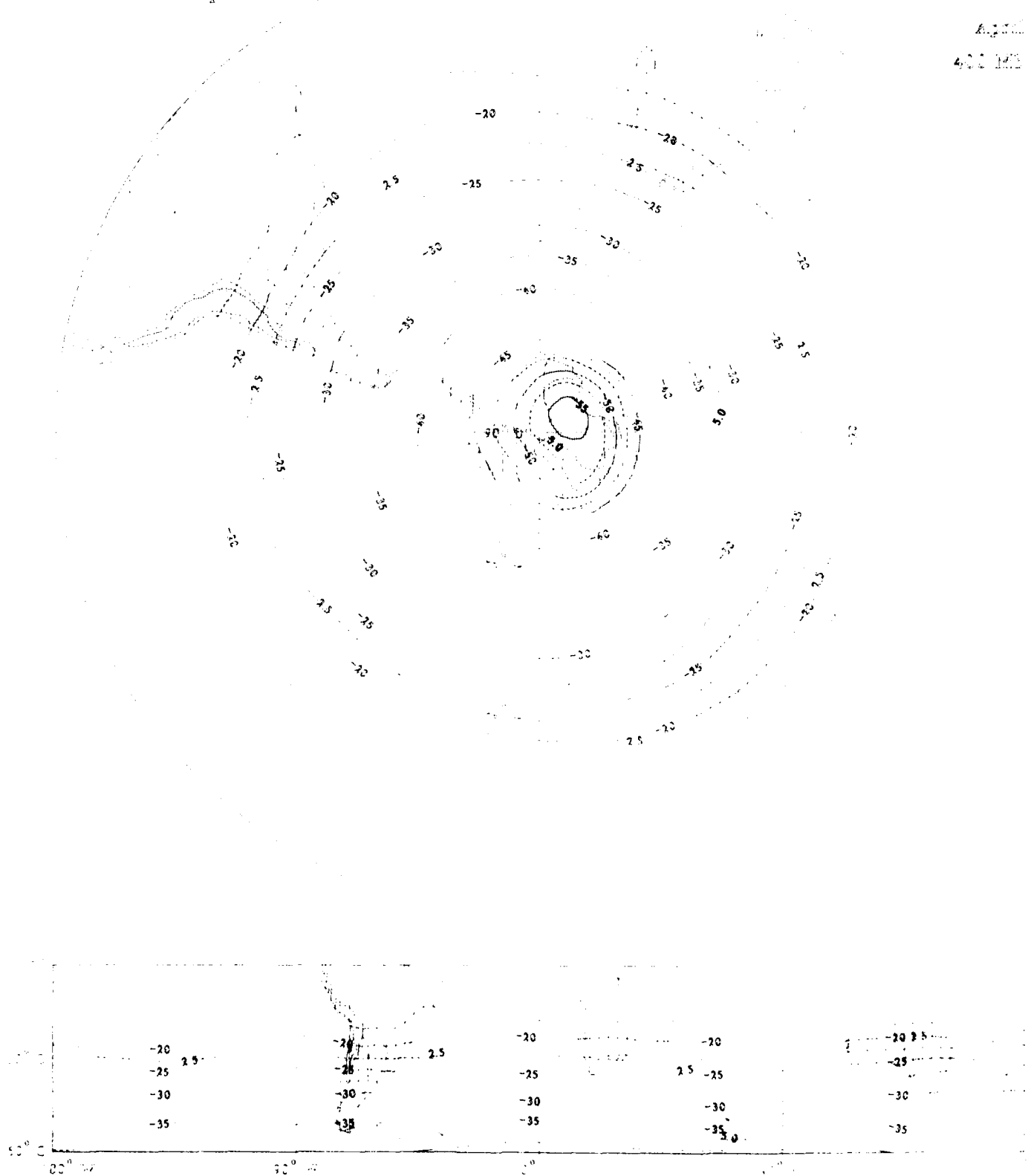
Upper Air Climatology
Southern Hemisphere

Mean Temperature (°C)

Sea Level (Cont'd)

April

400 MB



Mean Temperature (°C)

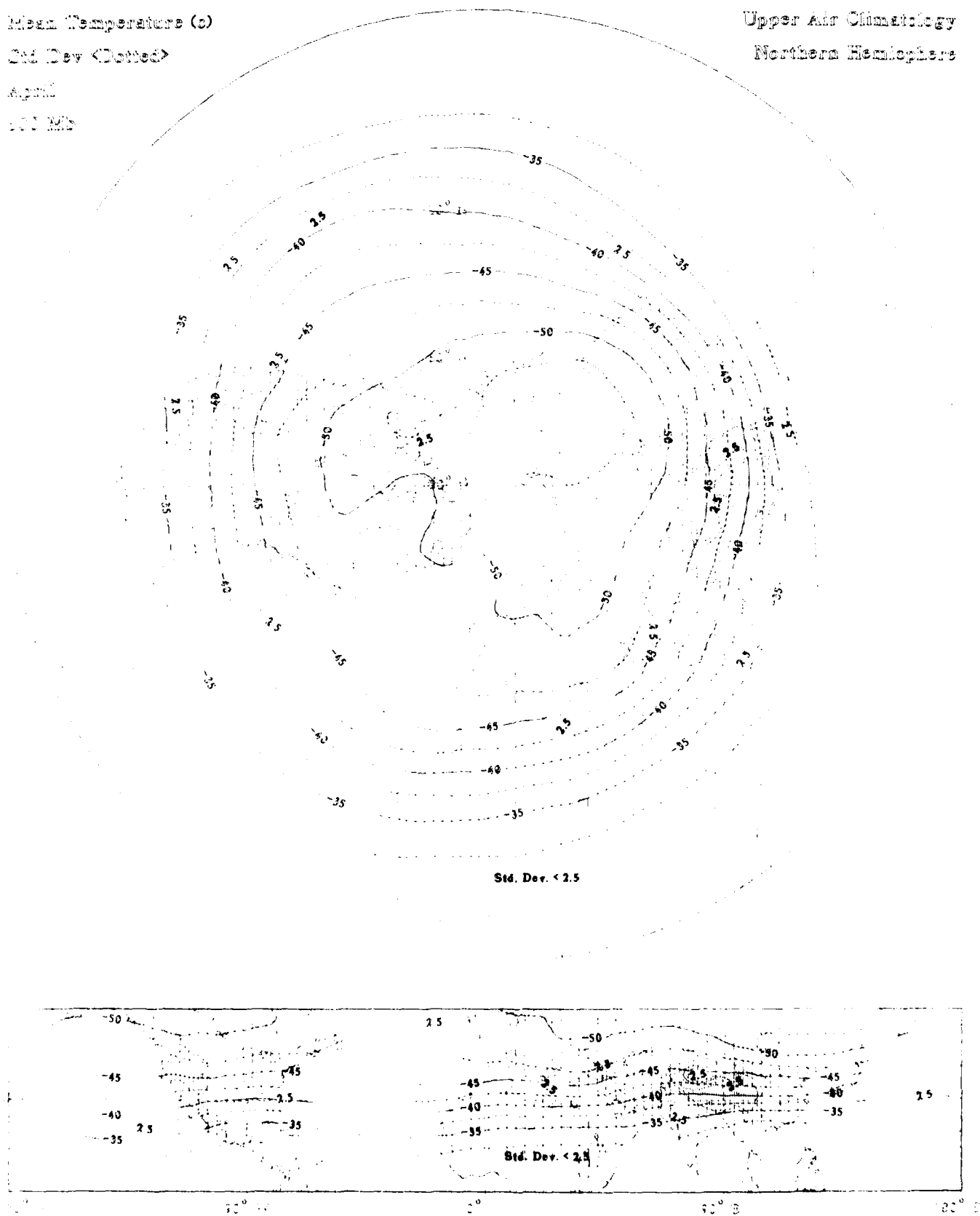
Std. Dev. (Dotted)

April

100 MB

Upper Air Climatology

Northern Hemisphere



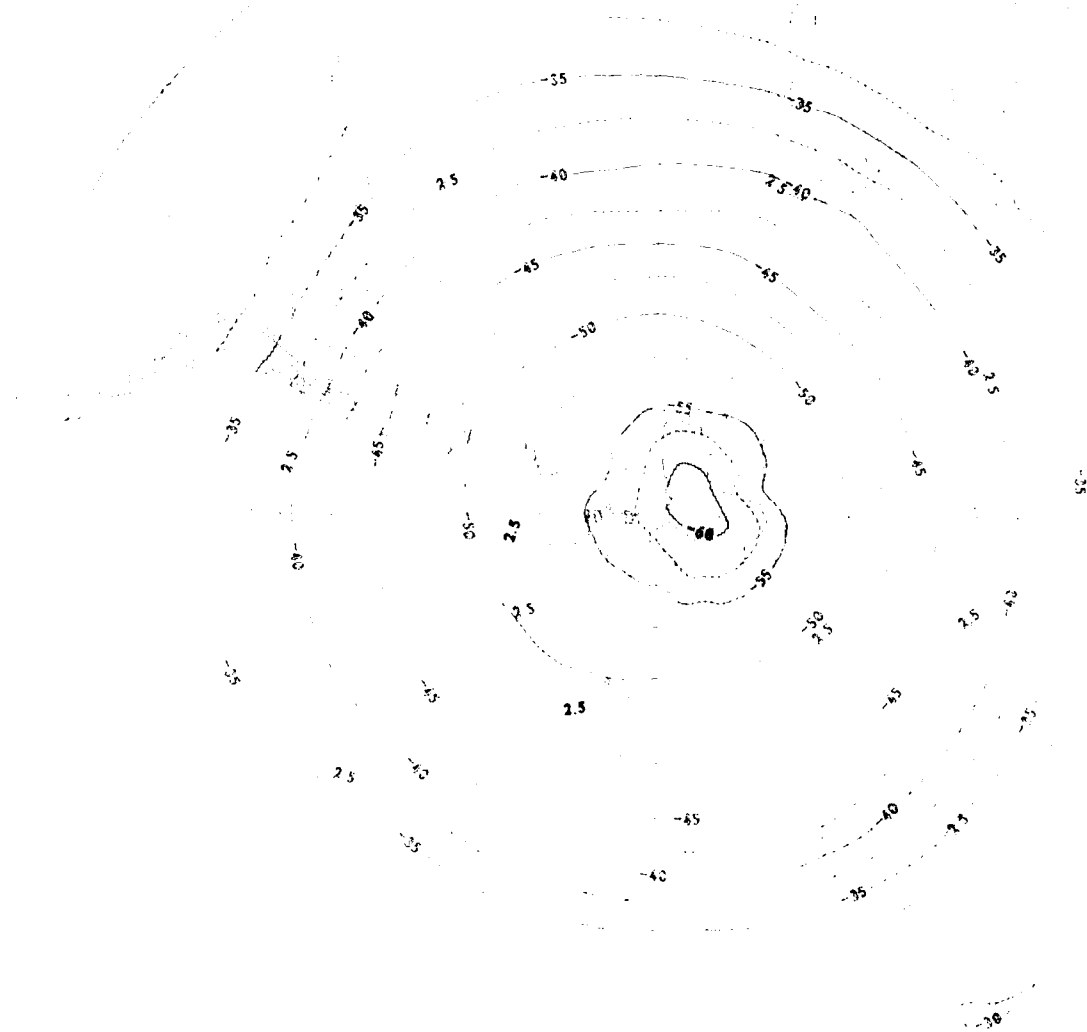
Upper Air Climatology
Southern Hemisphere

Mean Temperature (°C)

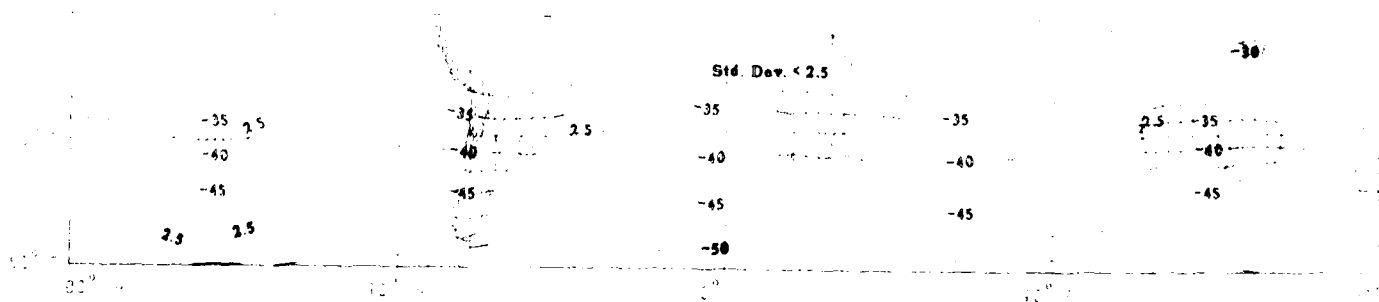
Std. Dev. < 0.5°C >

April

100 hPa



Std. Dev. < 2.5



Mean Temperature (c)

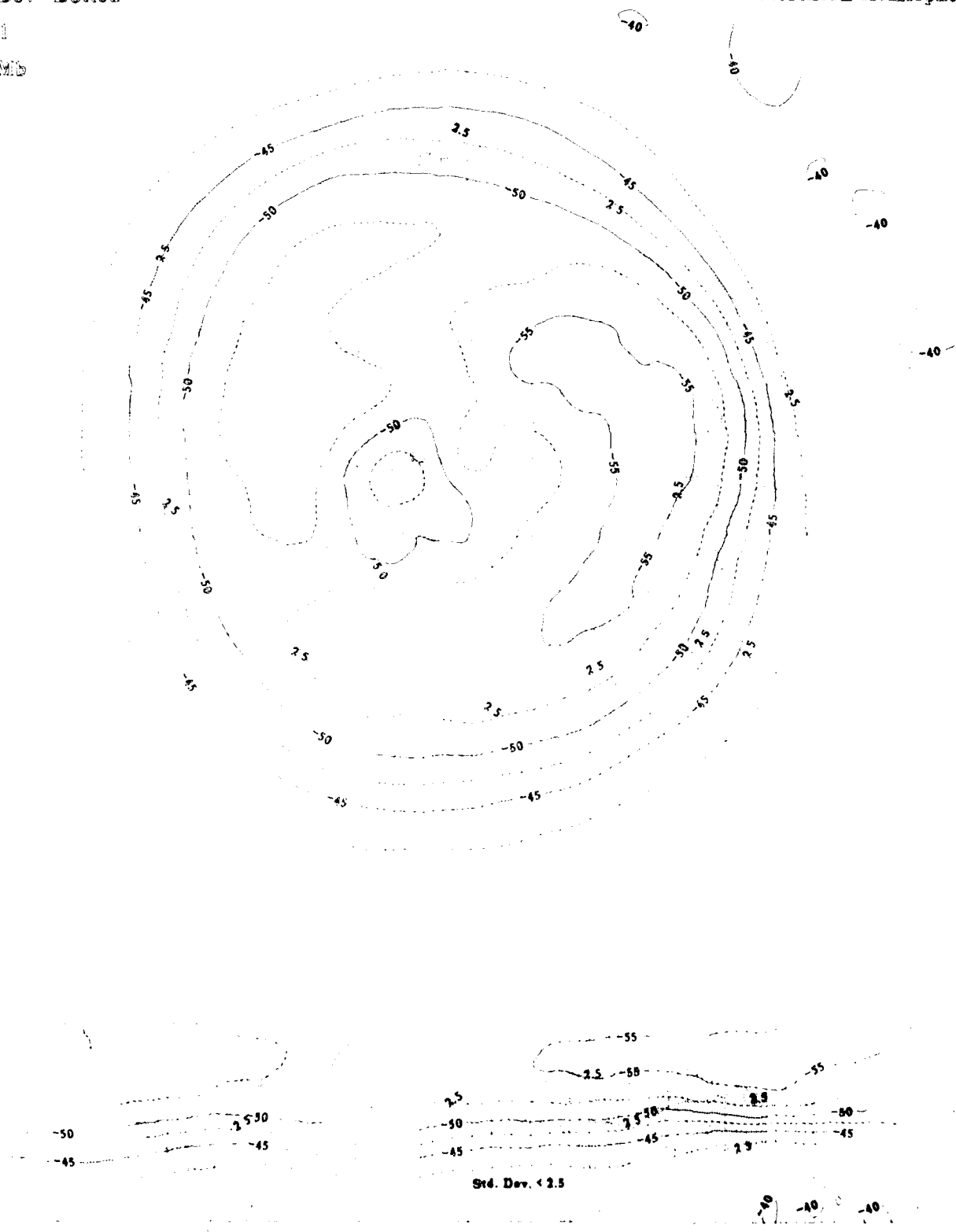
Std Dev <Dotted>

April

250 MB

Upper Air Climatology

Northern Hemisphere



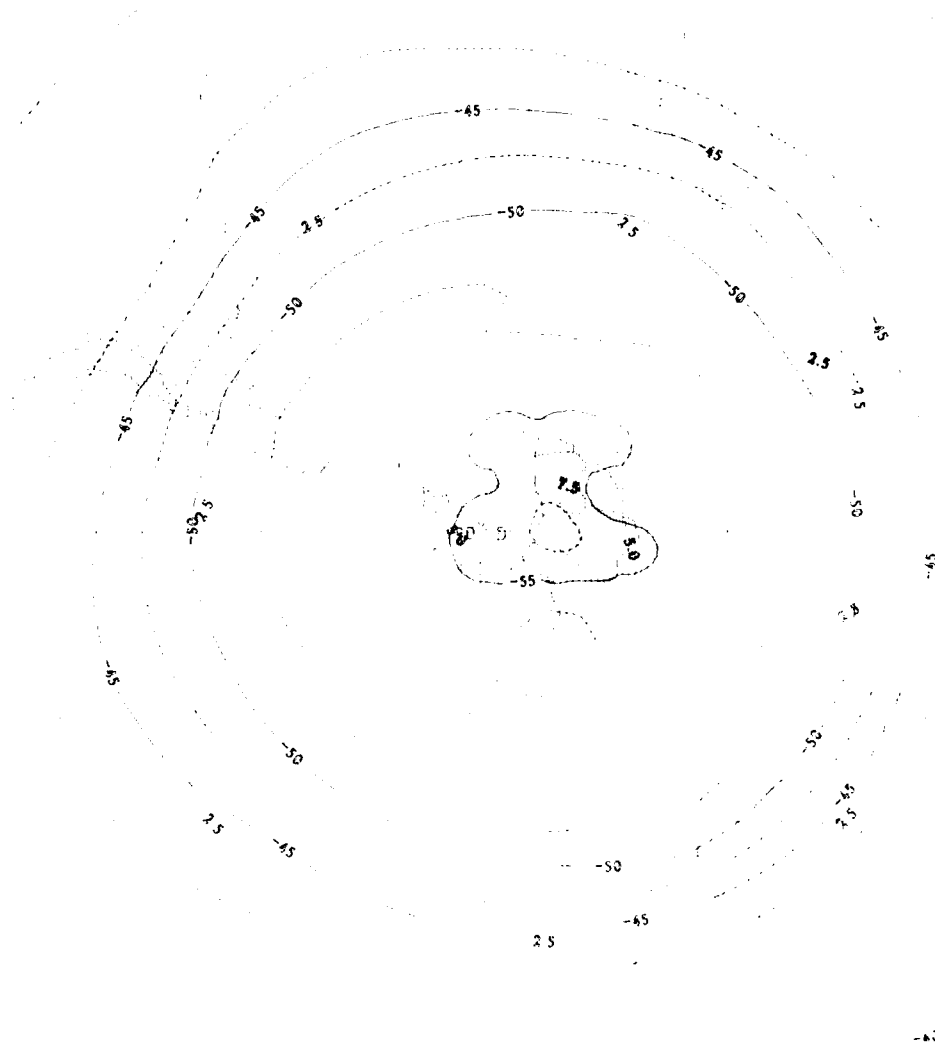
Upper Air Climatology
Southern Hemisphere

Mean Temperature (°C)

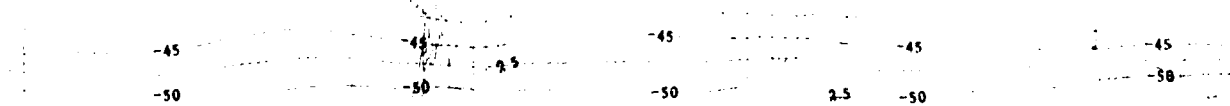
Std Dev (Ceter)

April

250 MB



Std. Dev. < 2.5



Mean Temperature (°C)

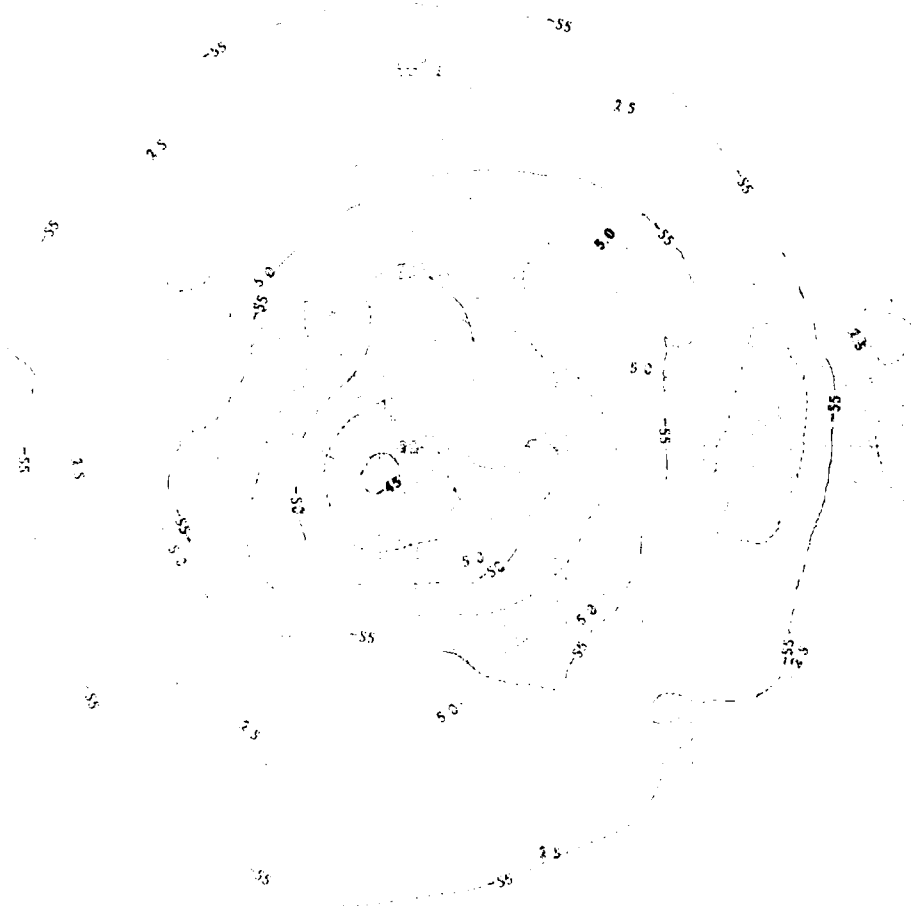
Day Day (Contour)

Figure

1. 1951

Upper and Lower

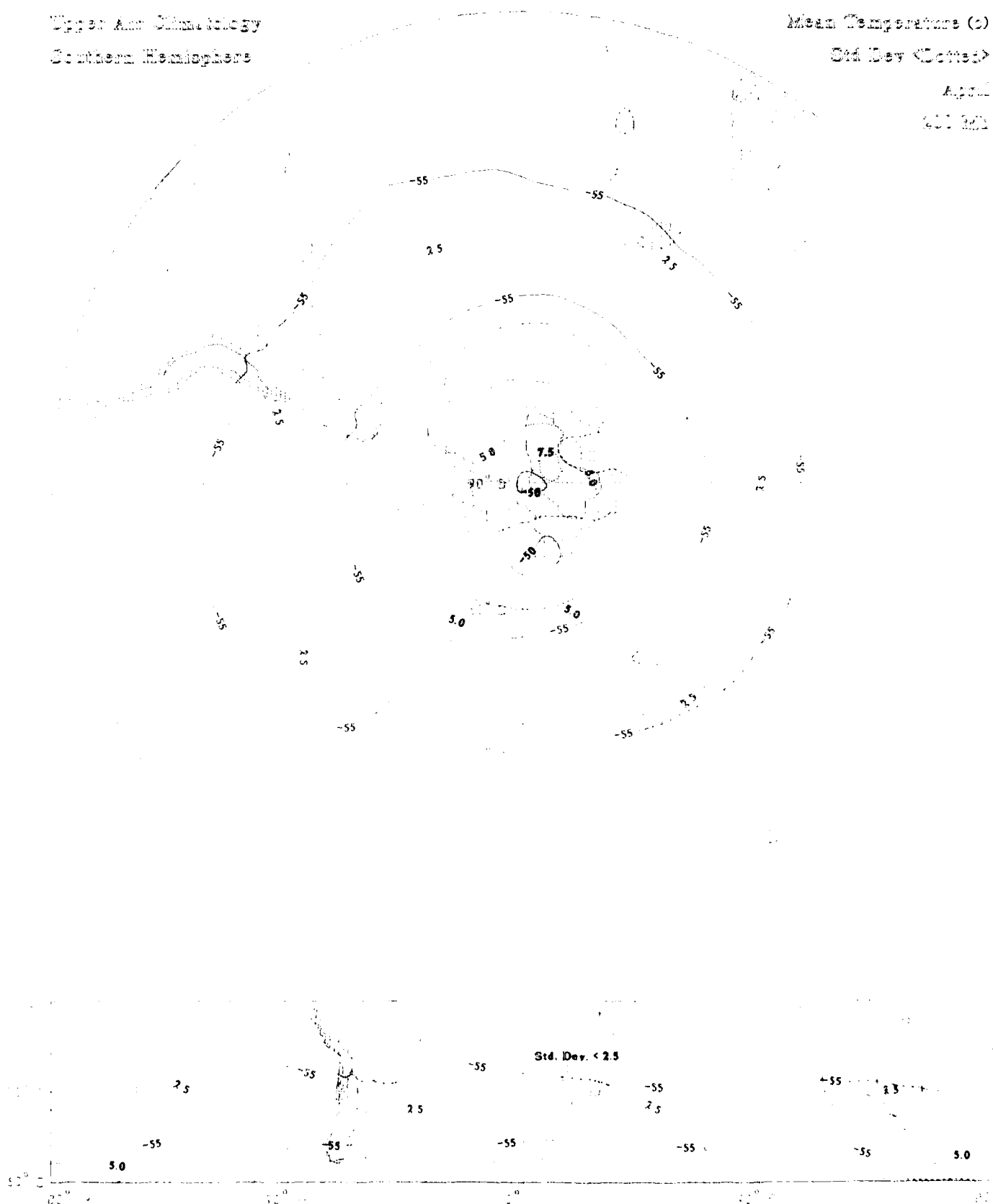
Northern Hemisphere



Upper Air Climatology
Southern Hemisphere

Mean Temperature (°C)
Old Day Climate

April
1951-1952



Mean Temperature (°C)

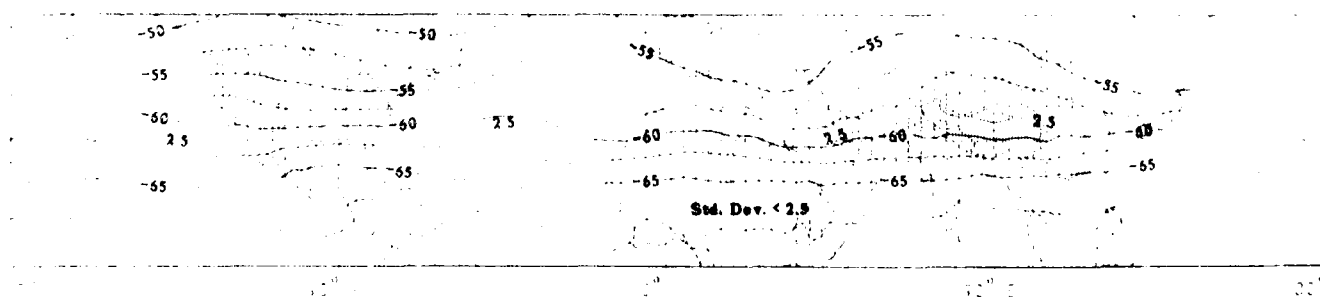
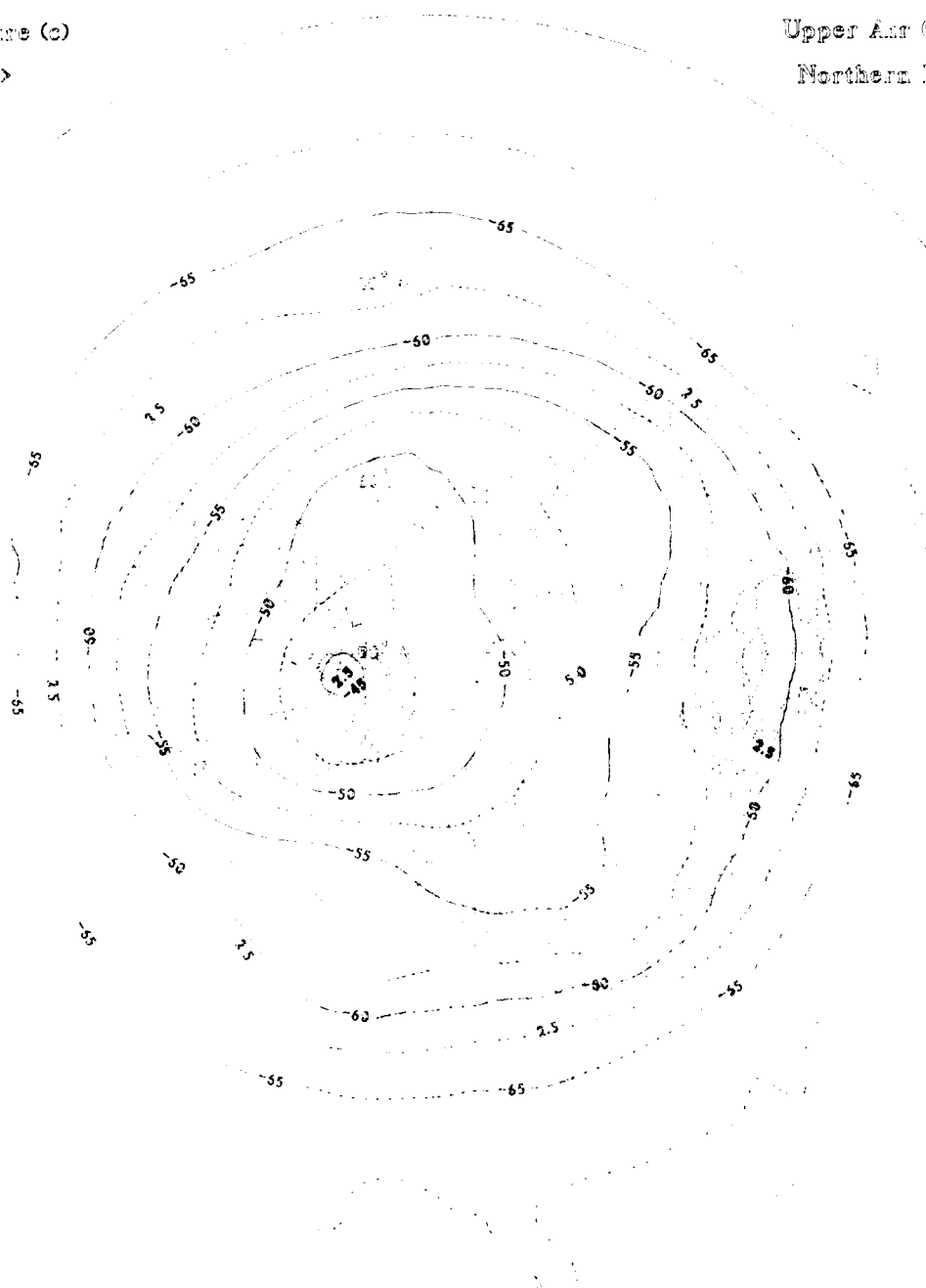
Std. Dev. (Dotted)

April

1951-1955

Upper Air Climatology

Northern Hemisphere



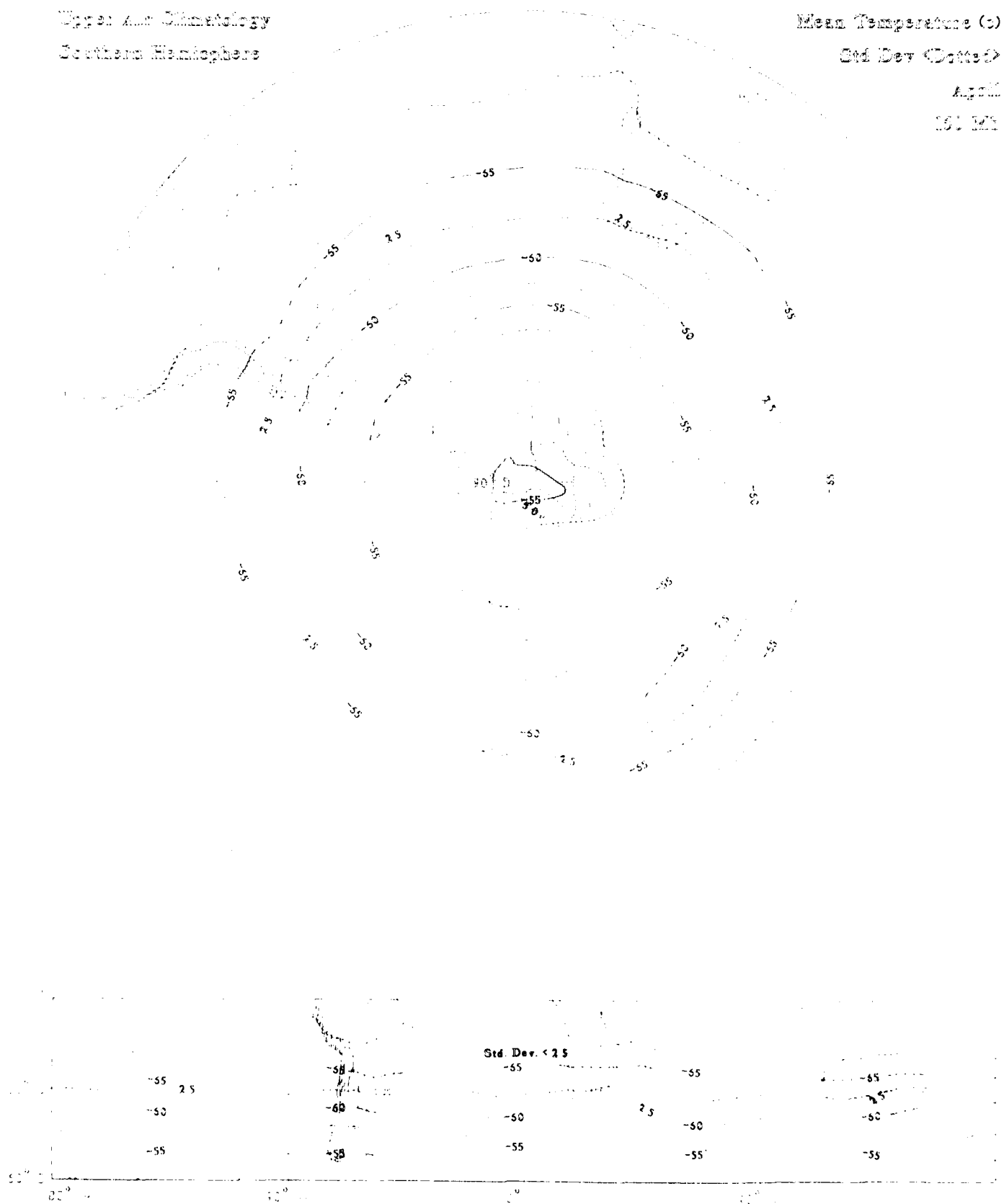
Upper Air Climatology
Southern Hemisphere

Mean Temperature (°C)

Std Dev (°C)

April

1951-1979



Mean Temperature (°C)

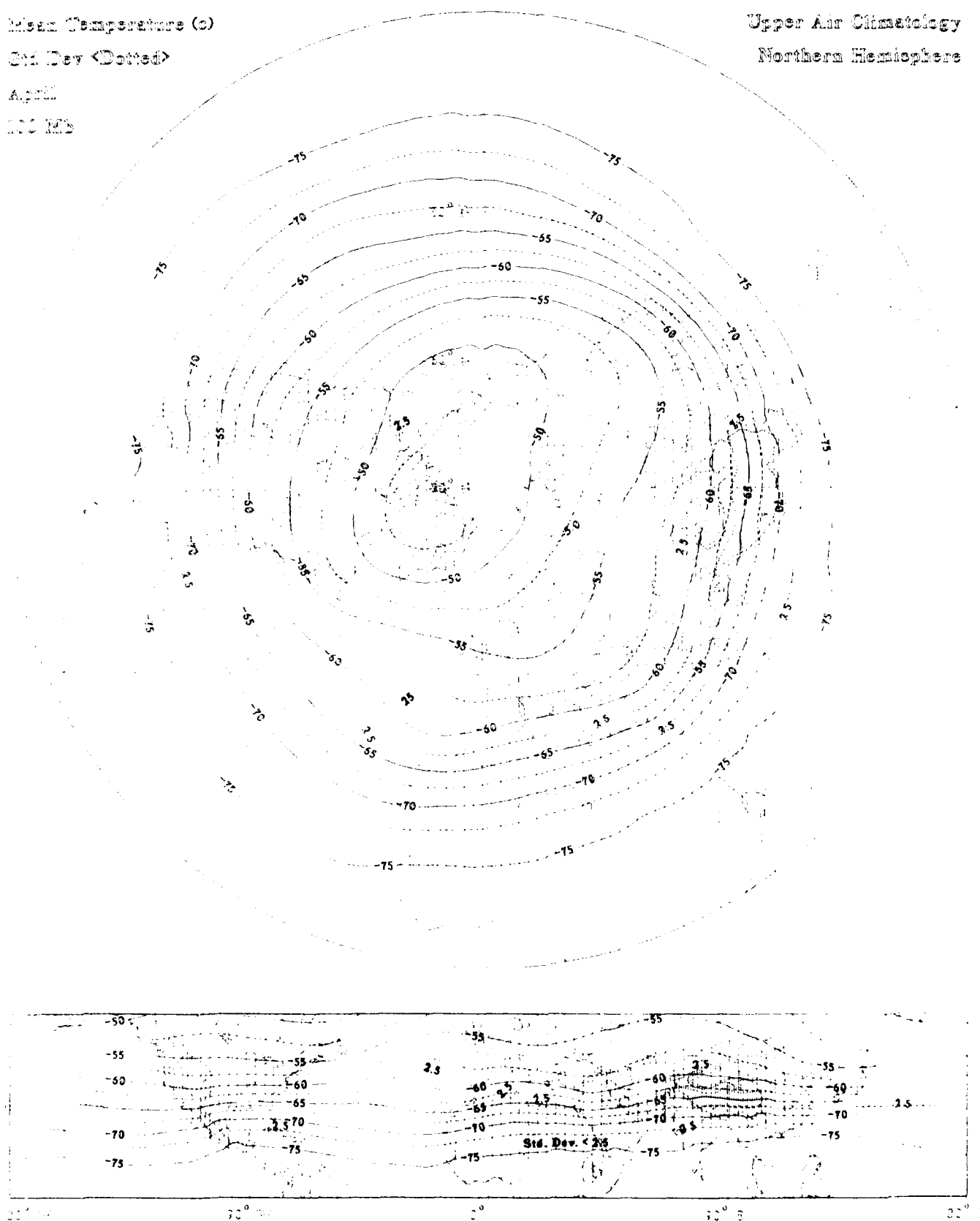
Std. Dev. (Dotted)

April

1950-1959

Upper Air Climatology

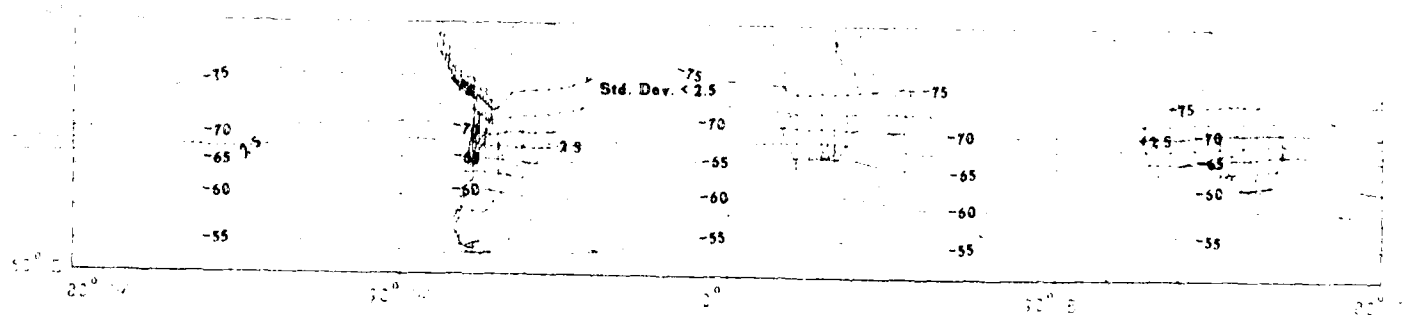
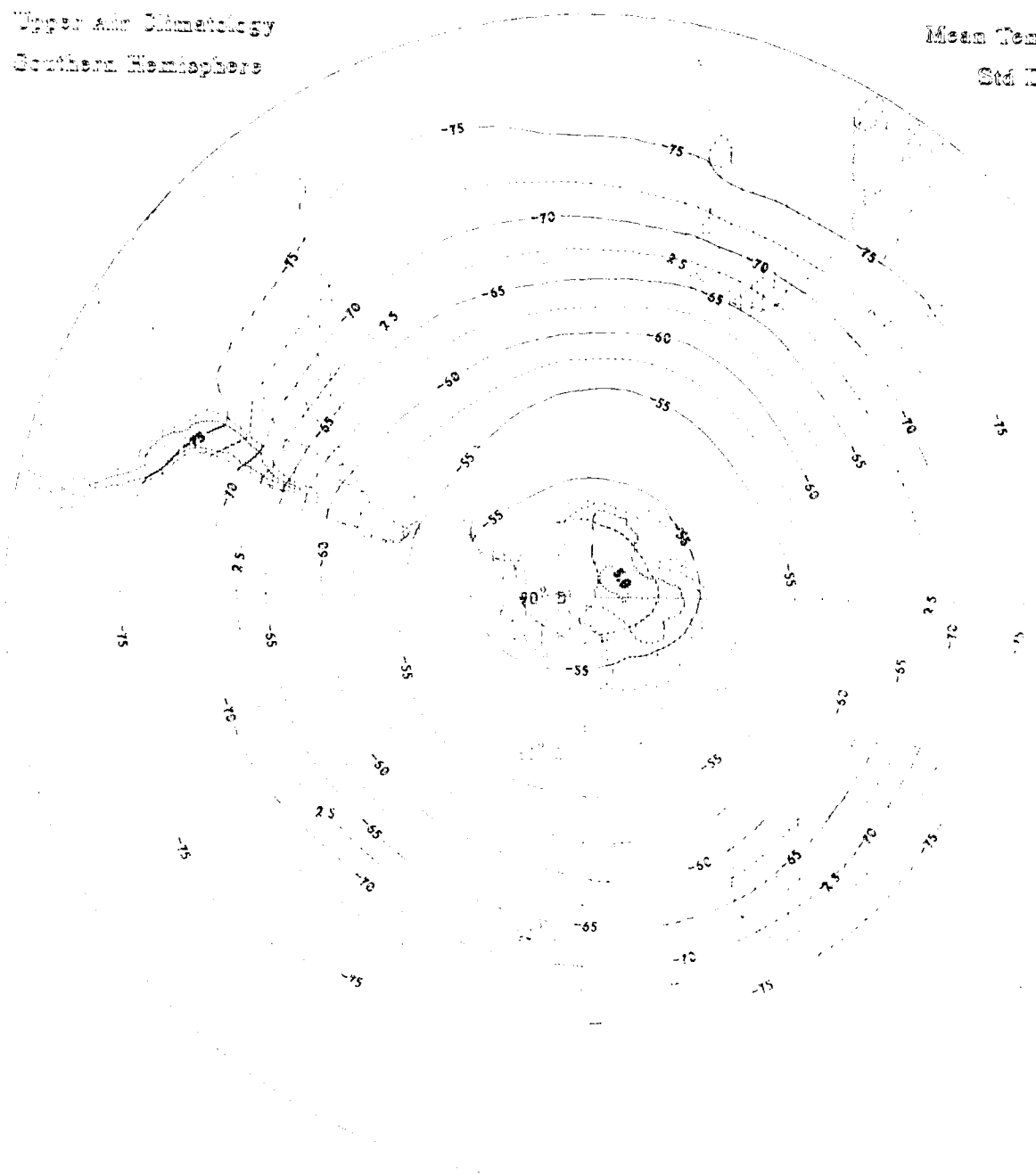
Northern Hemisphere



Upper Air Climatology
Southern Hemisphere

Mean Temperature (°C)
Std Dev (Cm/s)

April
100 MB



Mean Temperature (C)

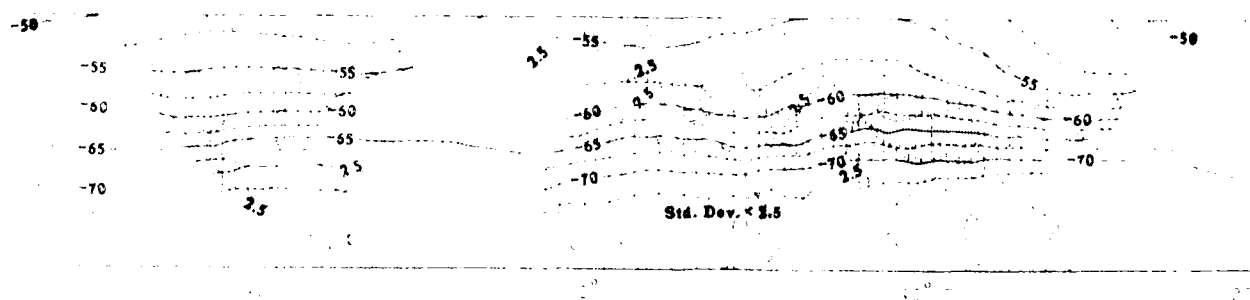
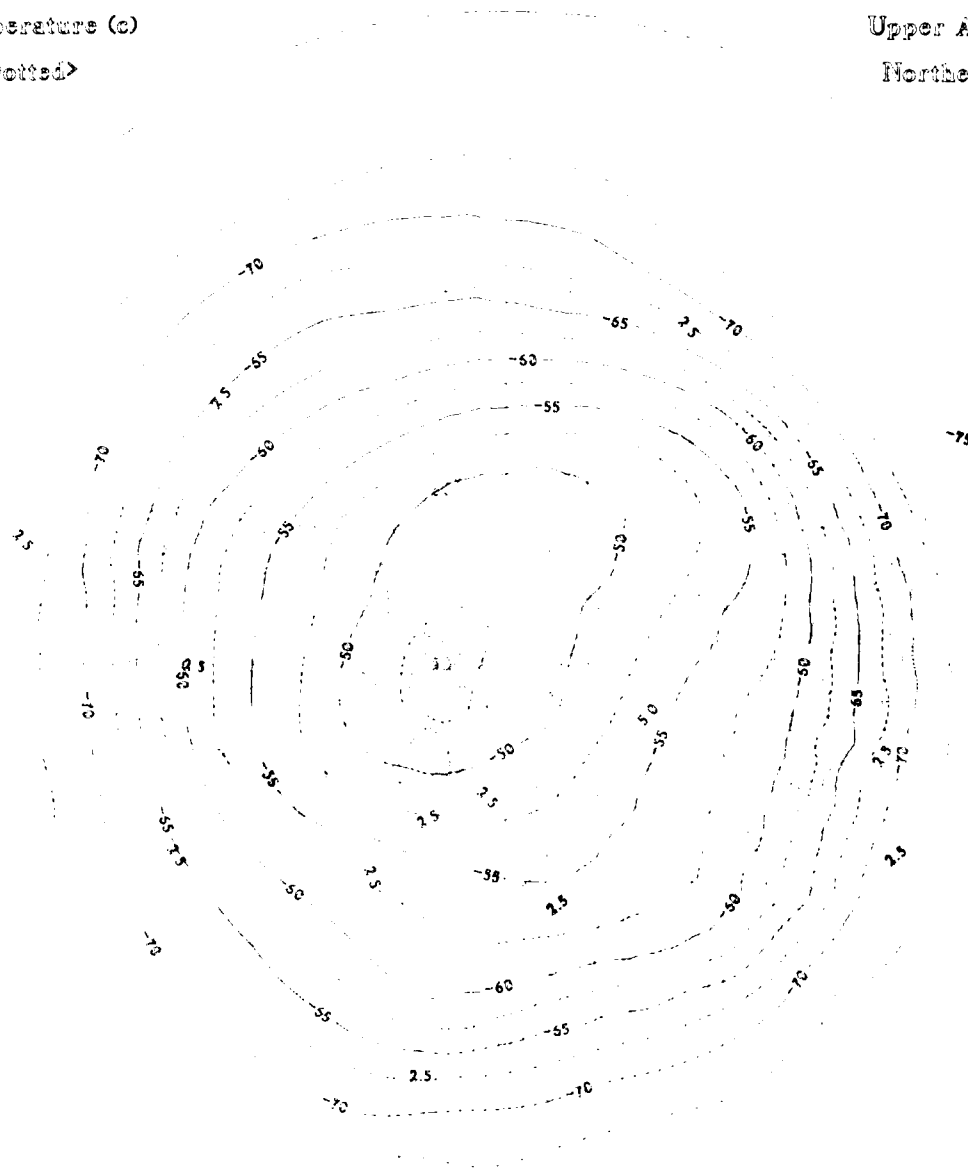
Std Dev (Dotted)

April

70 MB

Upper Air Climatology

Northern Hemisphere



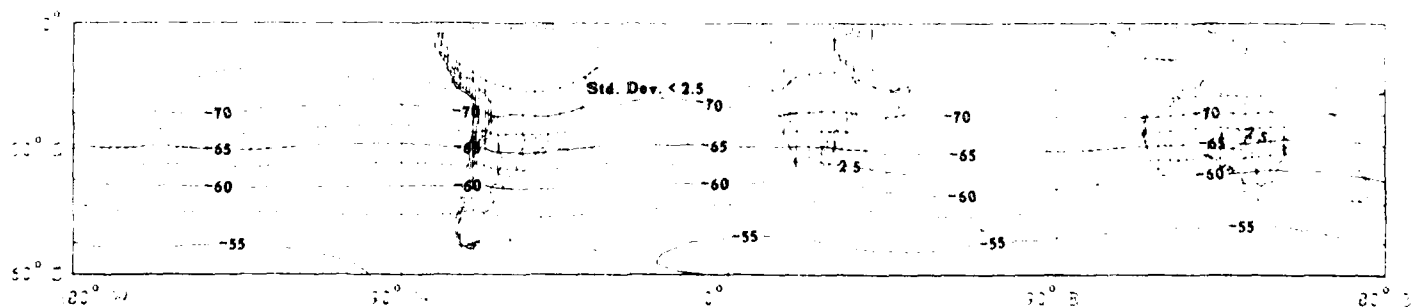
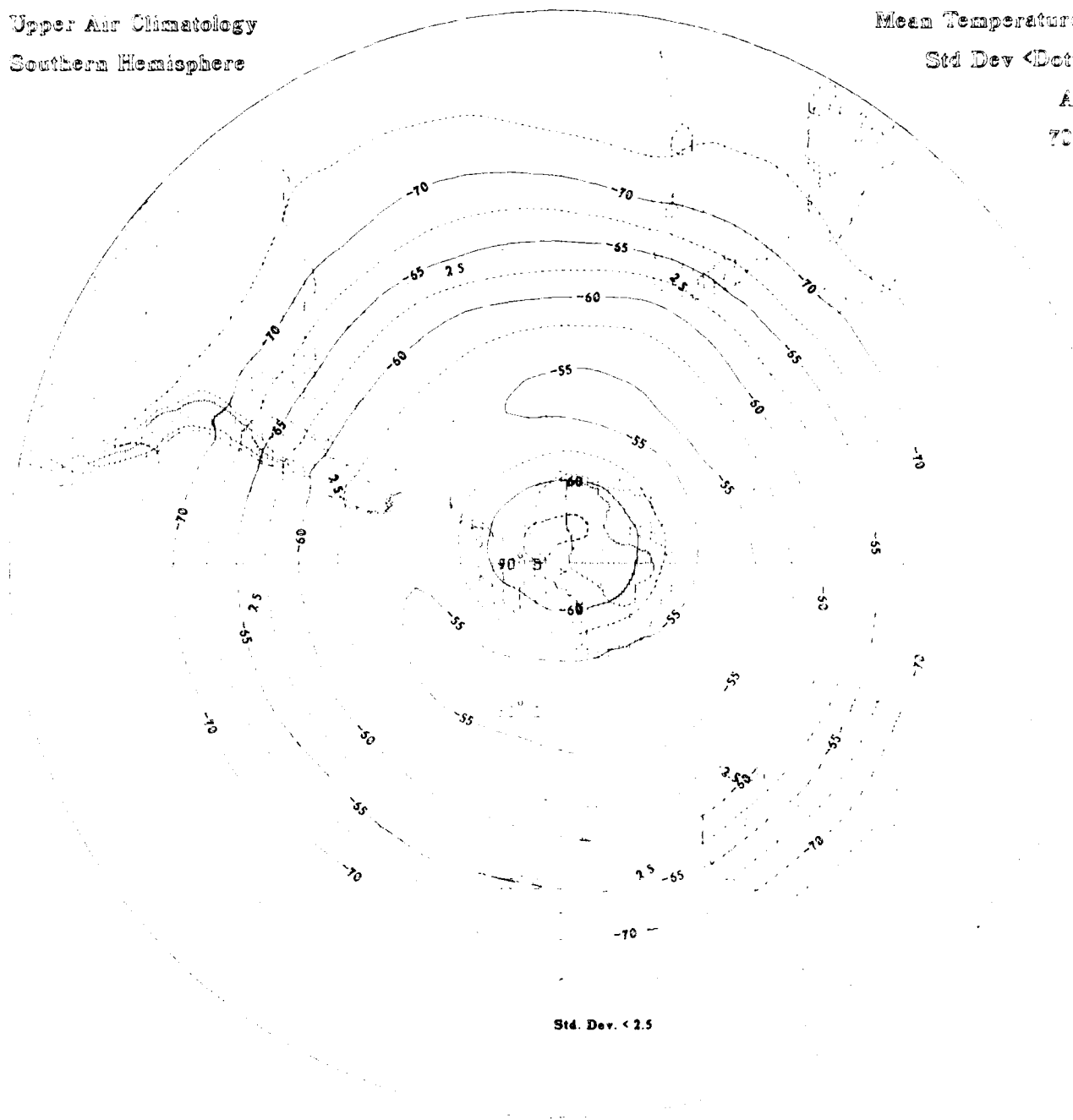
Upper Air Climatology
Southern Hemisphere

Mean Temperature (°C)

Std Dev <Dotted>

April

70 MB



Mean Temperature (c)

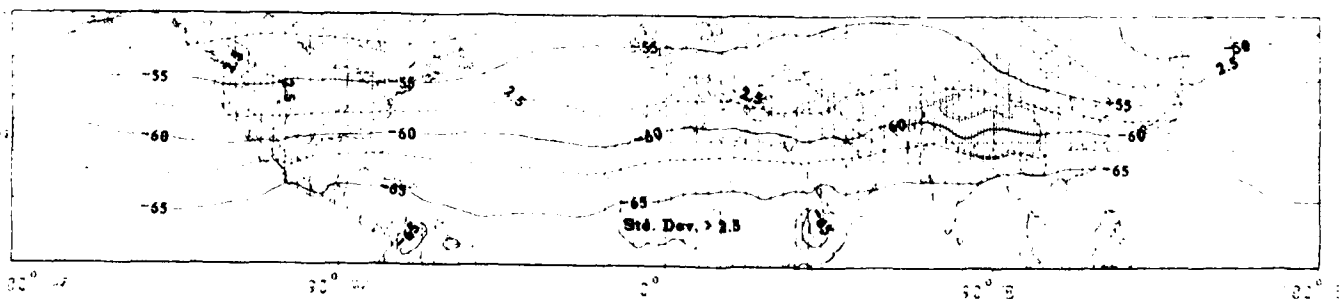
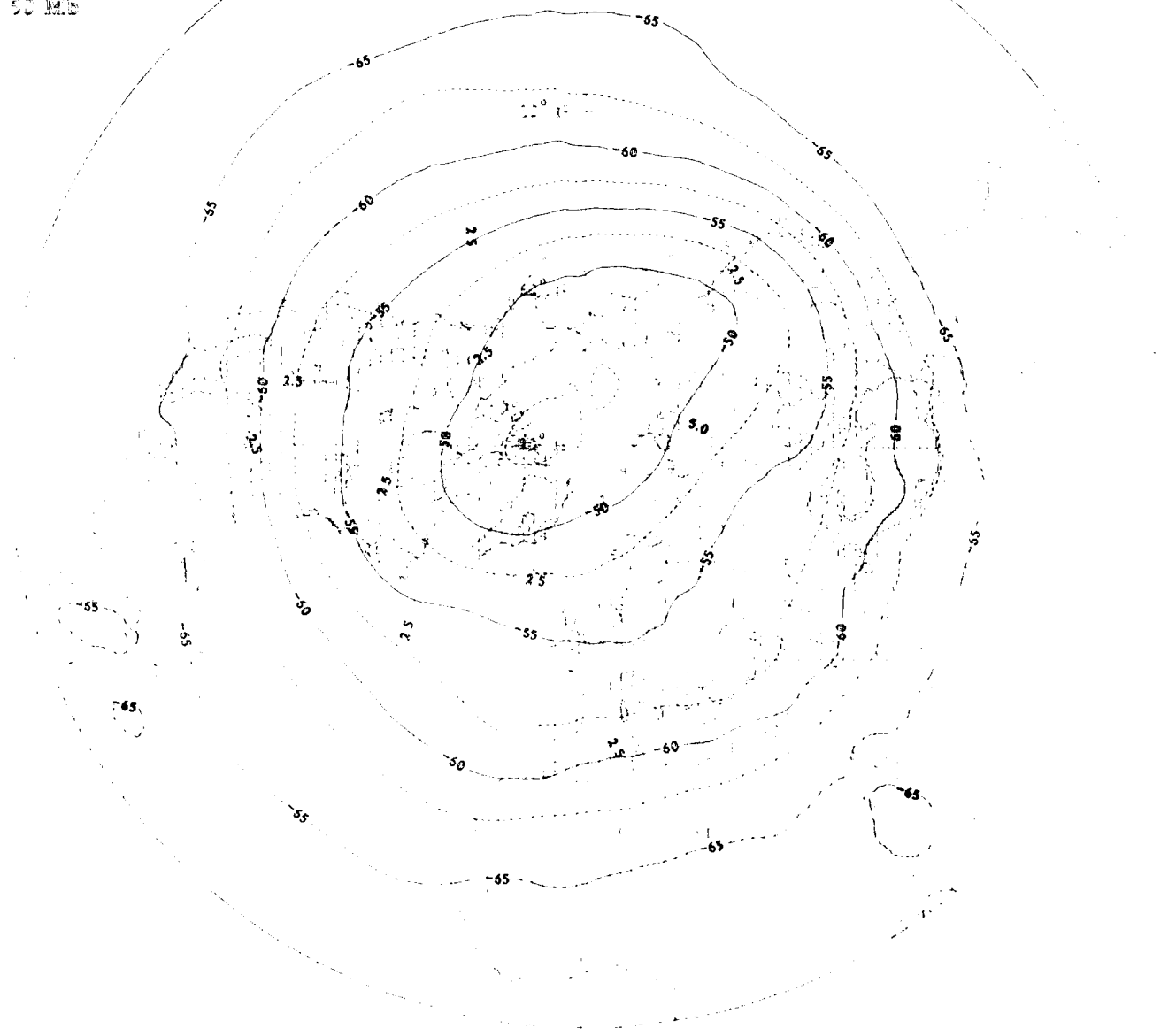
Std. Dev. <Dotted>

April

50 Mb

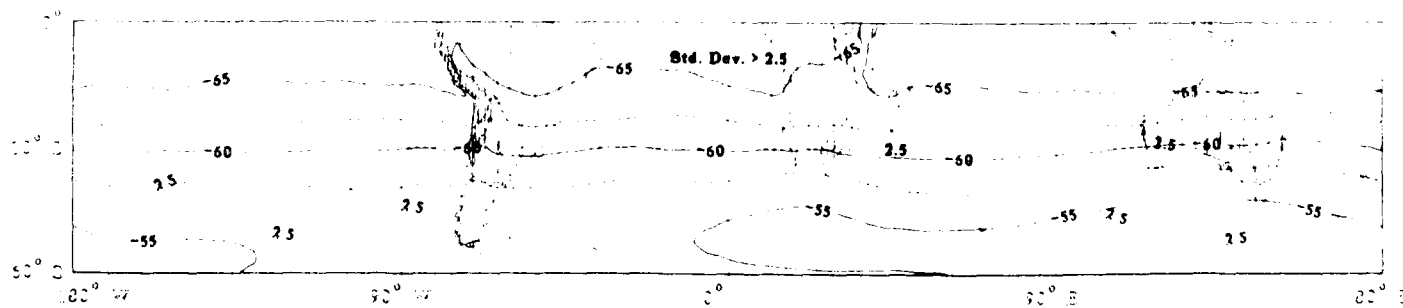
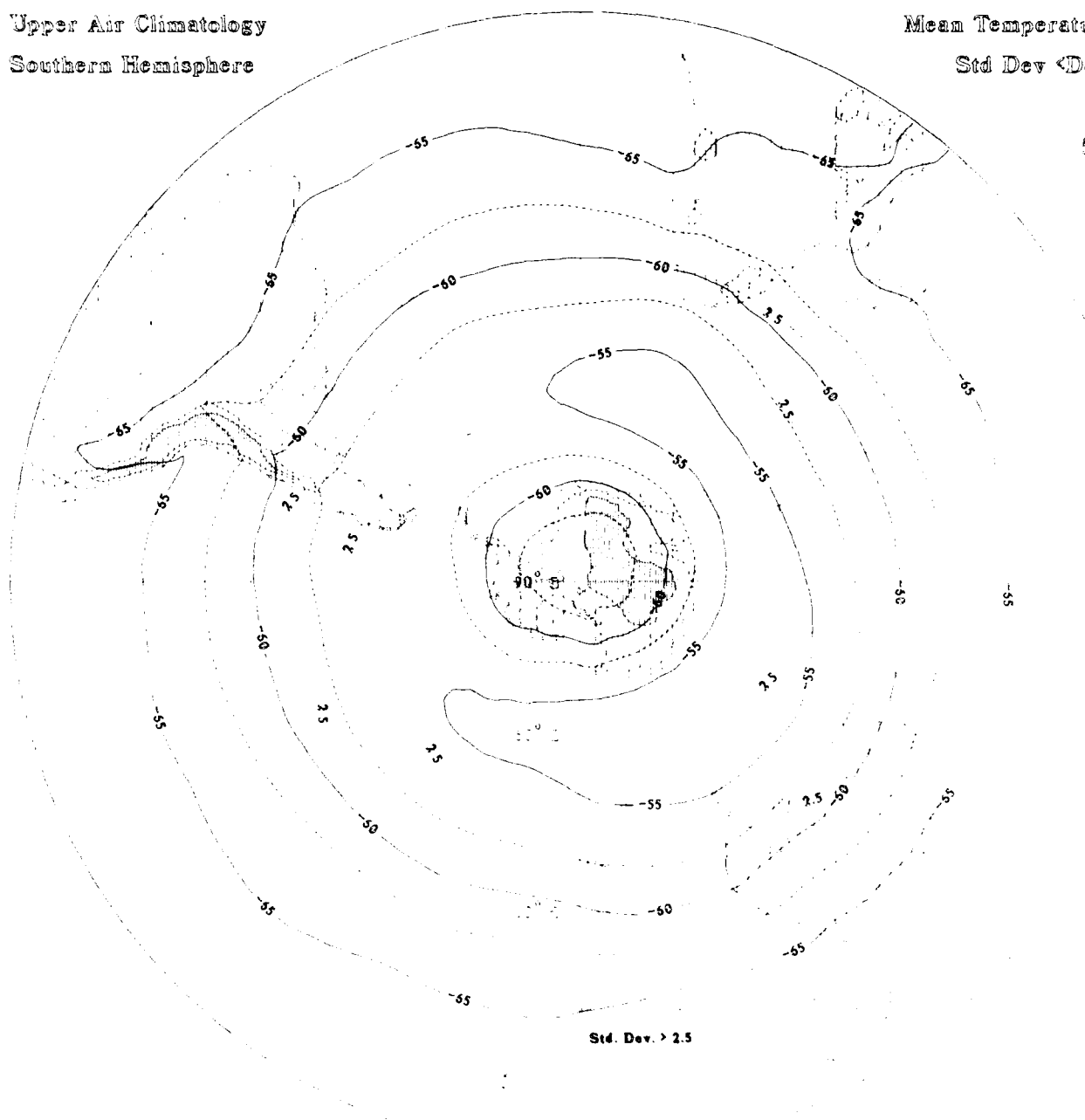
Upper Air Climatology

Northern Hemisphere



Upper Air Climatology
Southern Hemisphere

Mean Temperature (c)
Std Dev <Dotted>
April
50 MB



Mean Temperature (c)

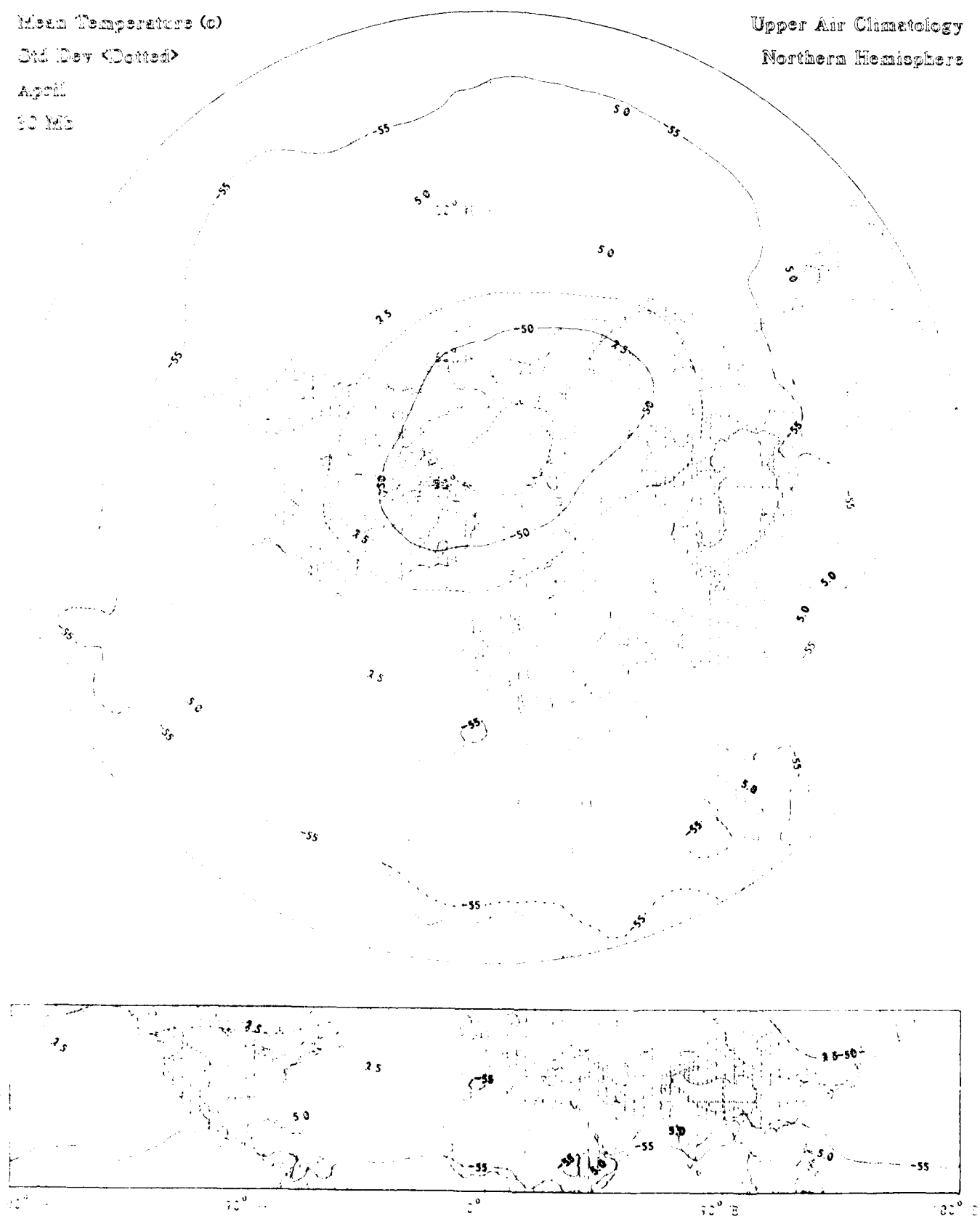
Std Dev (Dotted)

April

90 Mb

Upper Air Climatology

Northern Hemisphere



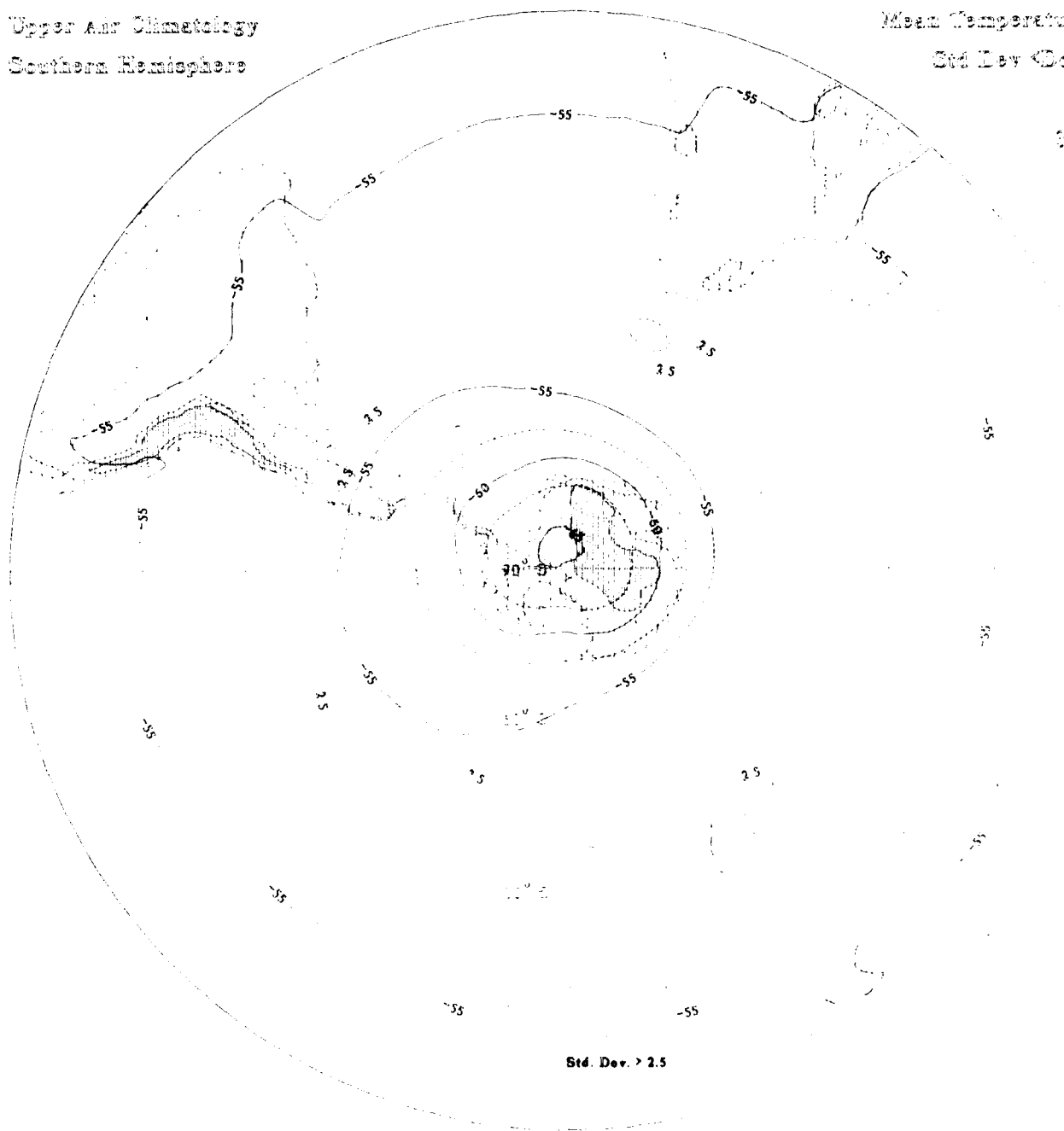
Upper Air Climatology
Southern Hemisphere

Mean Temperature (°C)

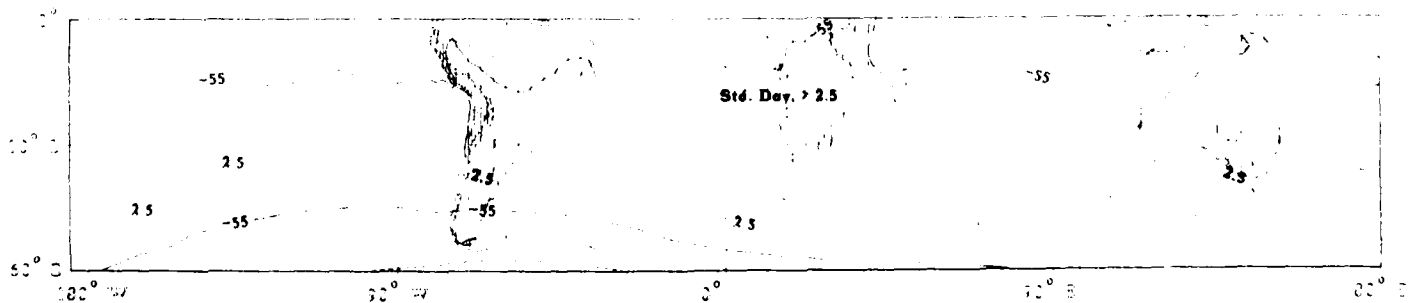
Std Dev (Dotted)

April

00 UTC



Std. Dev. > 2.5

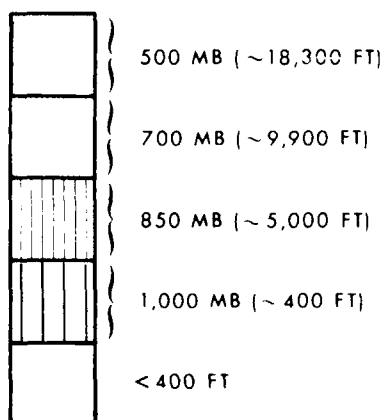


Std. Dev. > 2.5

DEW POINT
(6 LEVELS, 1000 TO 300 MB)

- Contours of mean dew point (solid and dashed lines) in °C; solids labeled, dashed intermediates unlabeled.
- Dew point labeled interval: 5°C
- Contours of standard deviation of dew point (dotted lines) in °C
- Standard deviation of dew point labeled interval: 2.5°C
- Contours blanked for geographic areas with elevations exceeding specified geopotential heights

ELEVATION SCALE



Mean Dew Point (c)

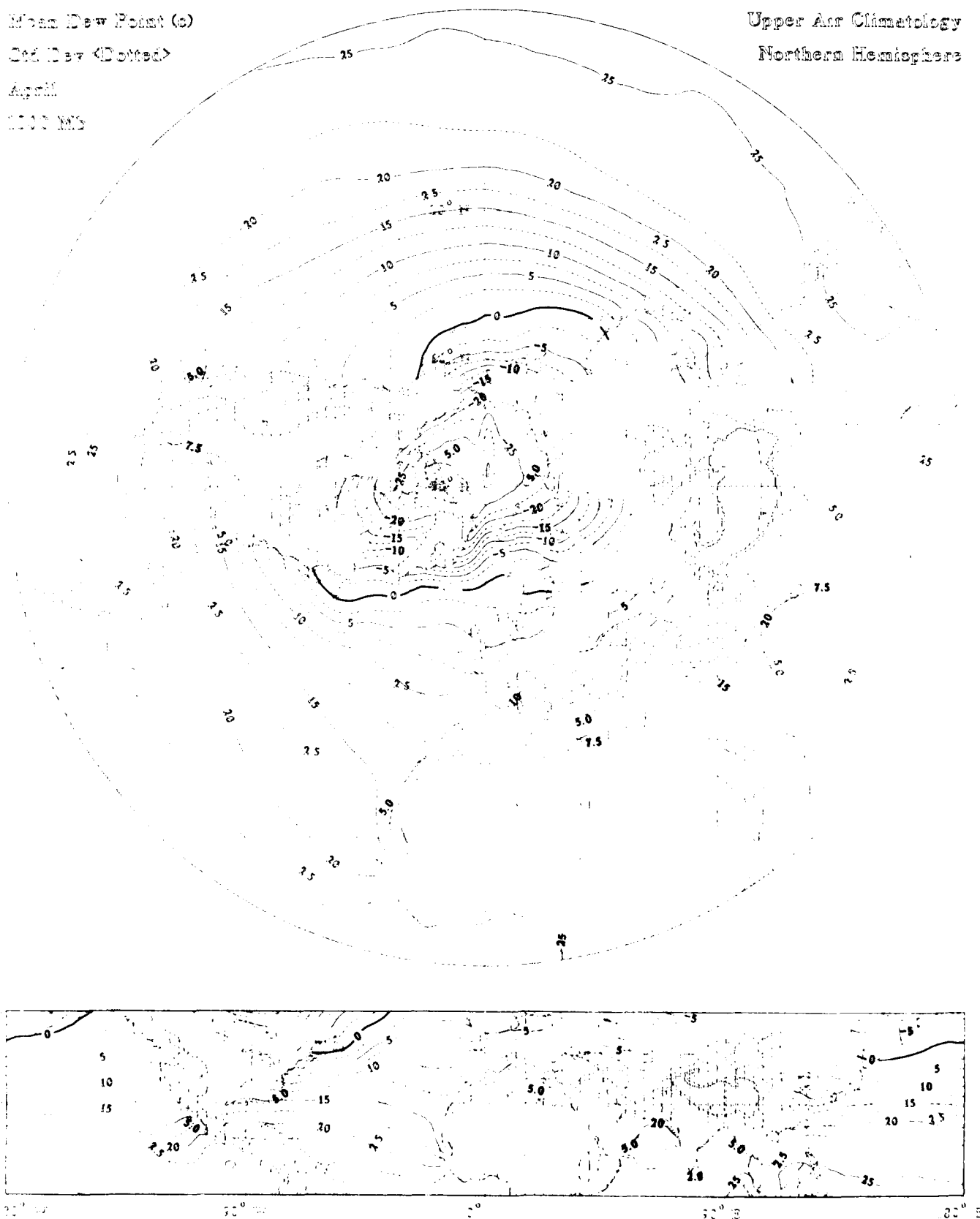
Std Dev (Dotted)

April

0000 MS

Upper Air Climatology

Northern Hemisphere



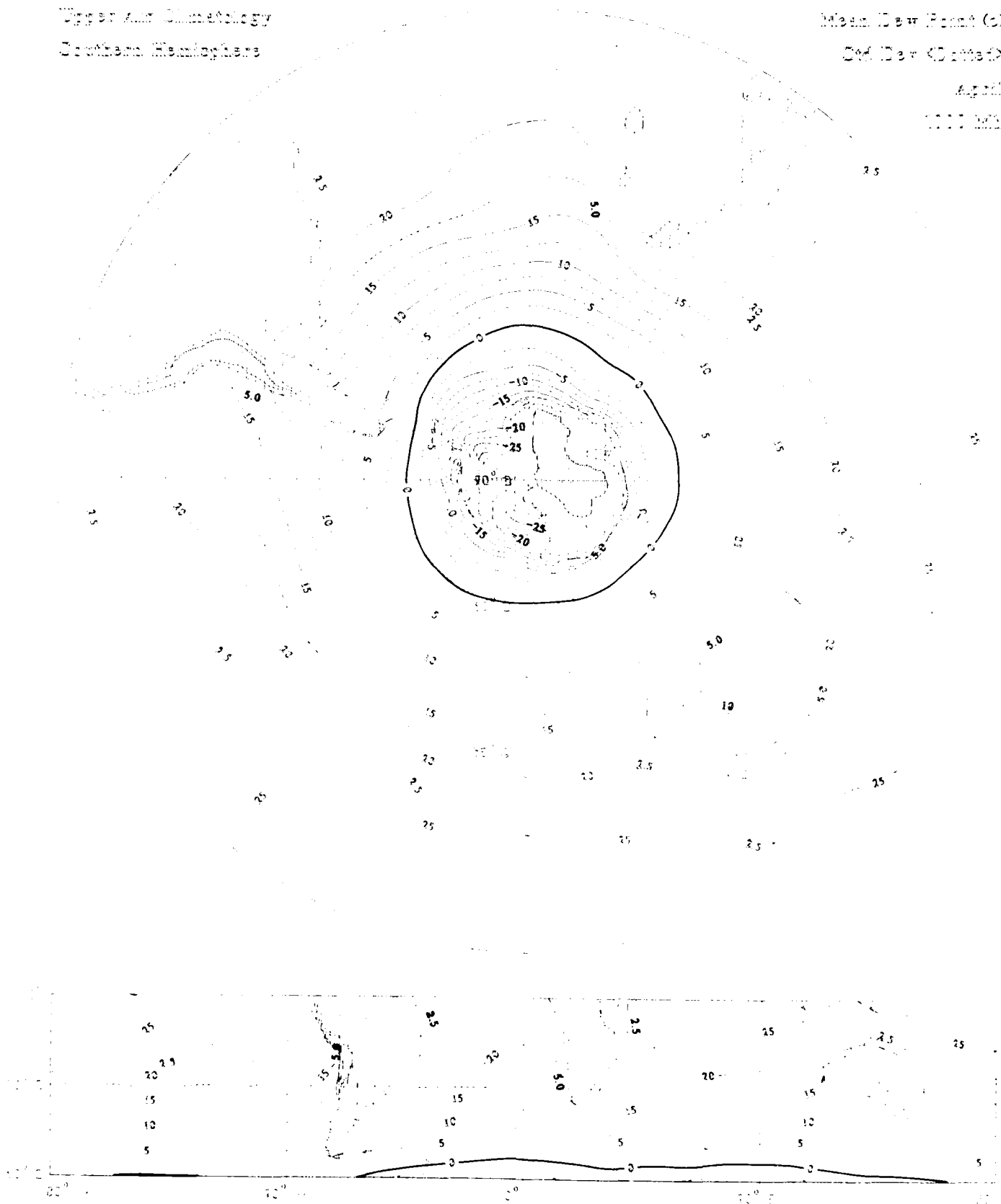
Upper Air Climatology
 Southern Hemisphere

Mean Dew Point (°C)

Std Dev (°C)

April

1971-1972



Mean Dew Point (°)

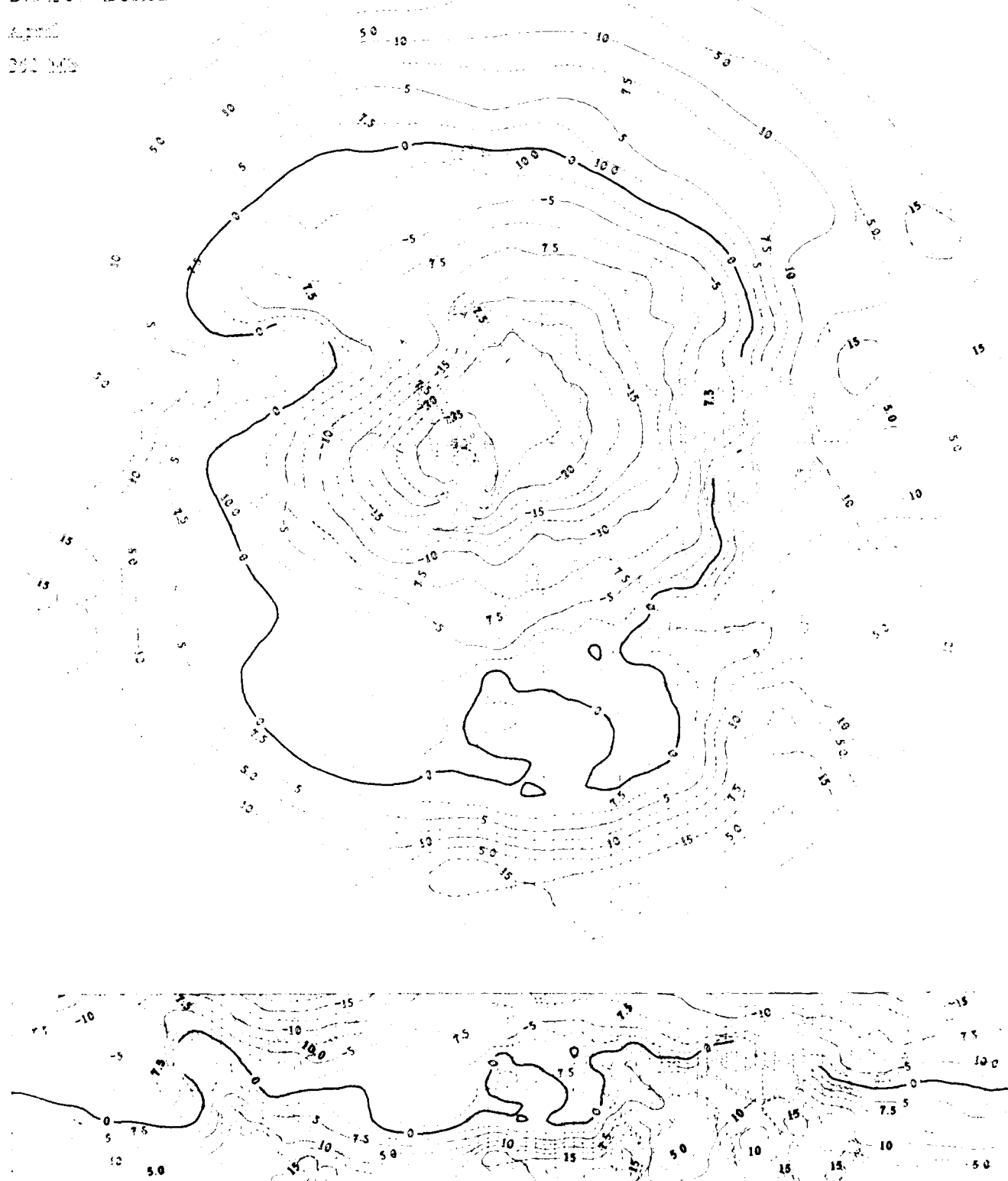
Sea Level (Corrected)

April

1961-1990

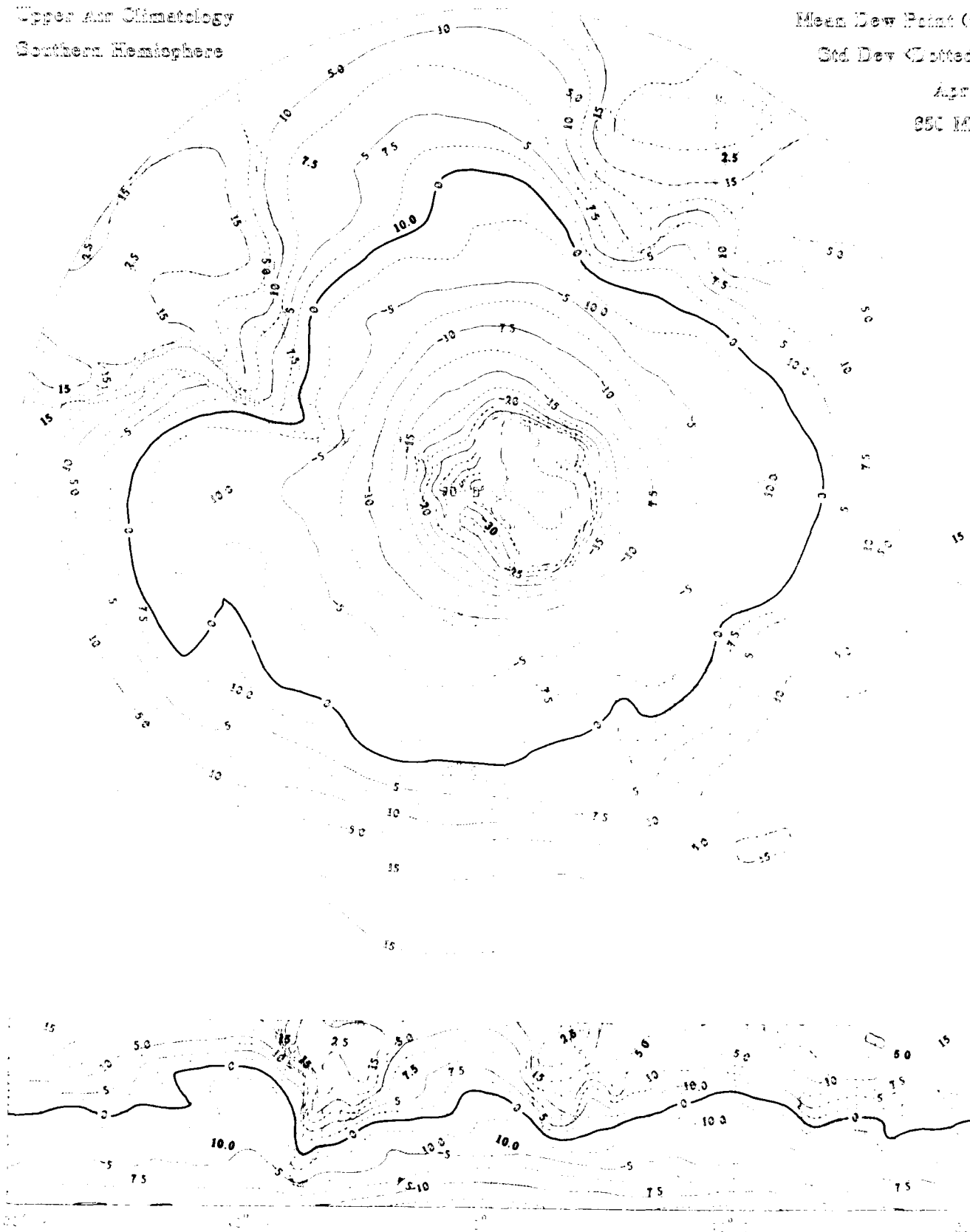
Upper Air Climatology

Northern Hemisphere



Upper Air Climatology
Southern Hemisphere

Mean Dew Point (°)
Std Dev (Dotted)
April
85C 141



Mean Dew Point (c)

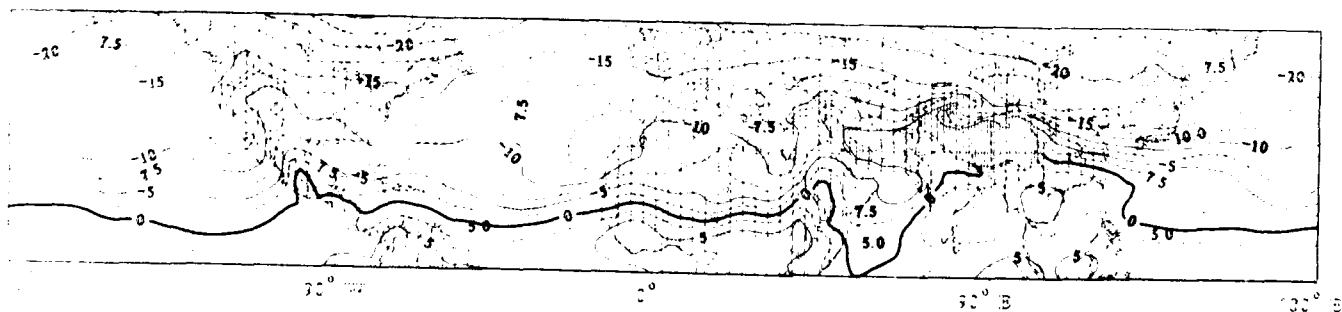
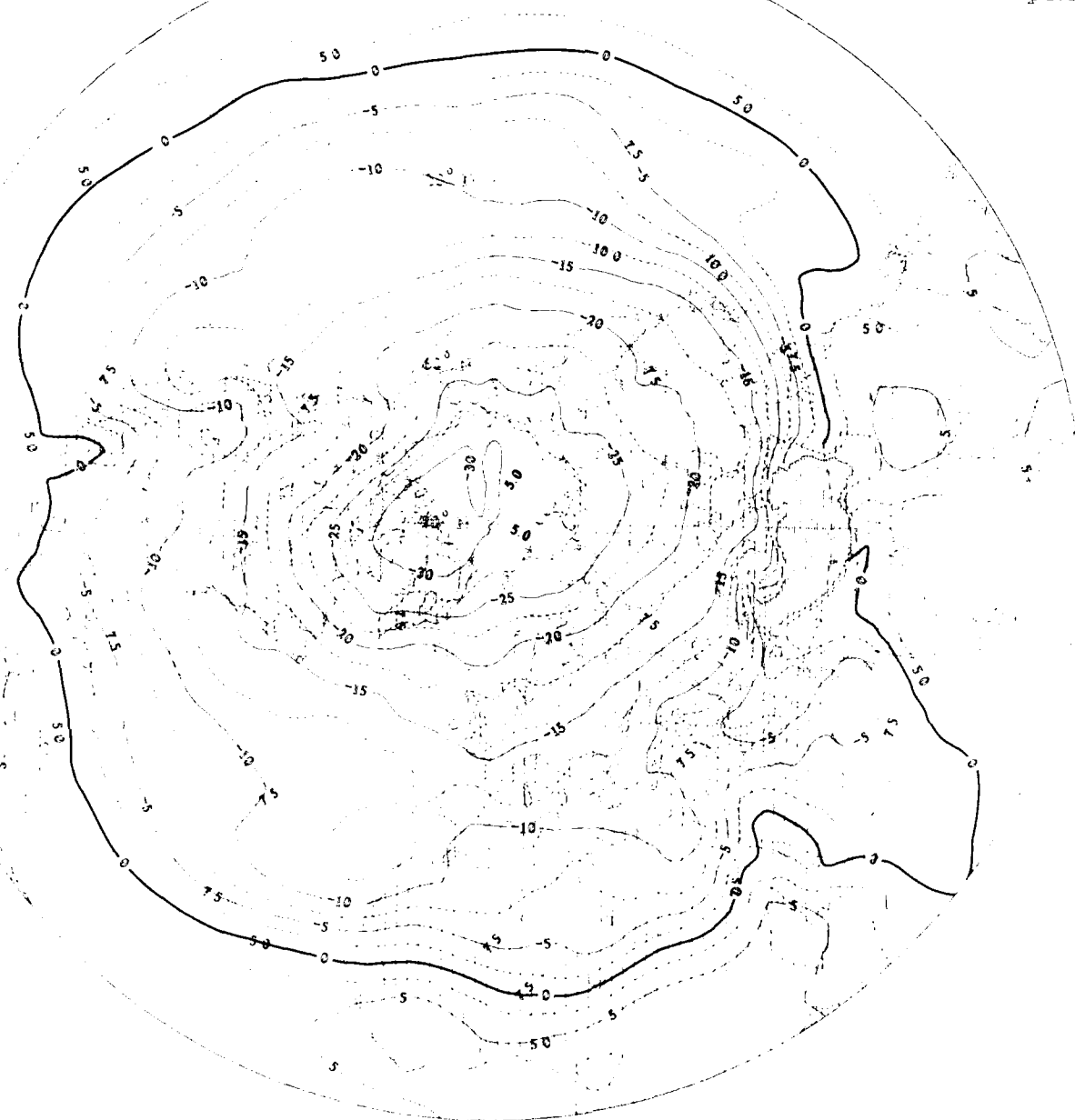
Oct-Dec (Cont'd)

April

1911-1919

Upper Air Climatology

Northern Hemisphere



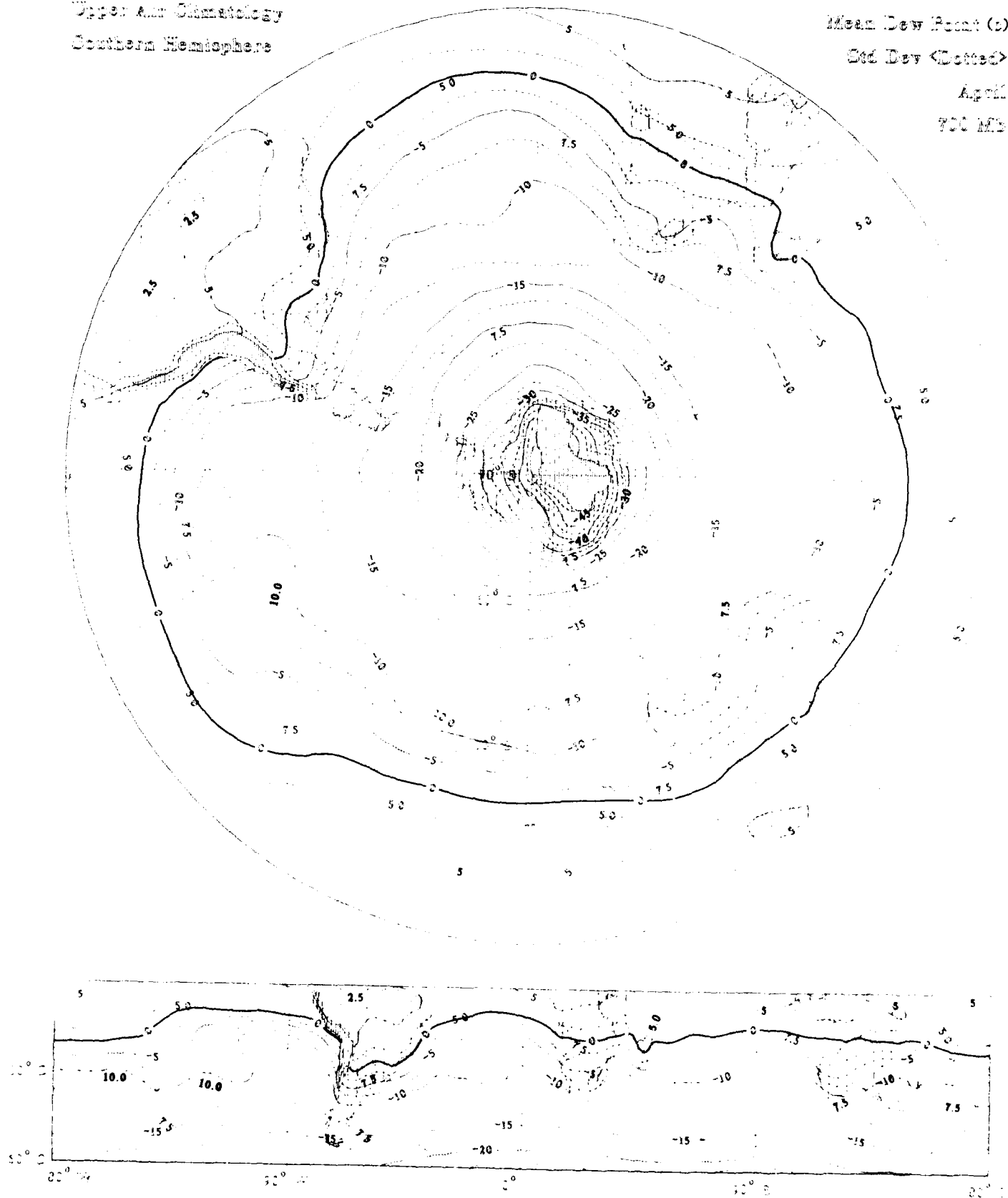
Upper Air Climatology
Southern Hemisphere

Mean Dew Point (°C)

Std Dev <Dotted>

April

700 MB



Mean Dew Point (c)

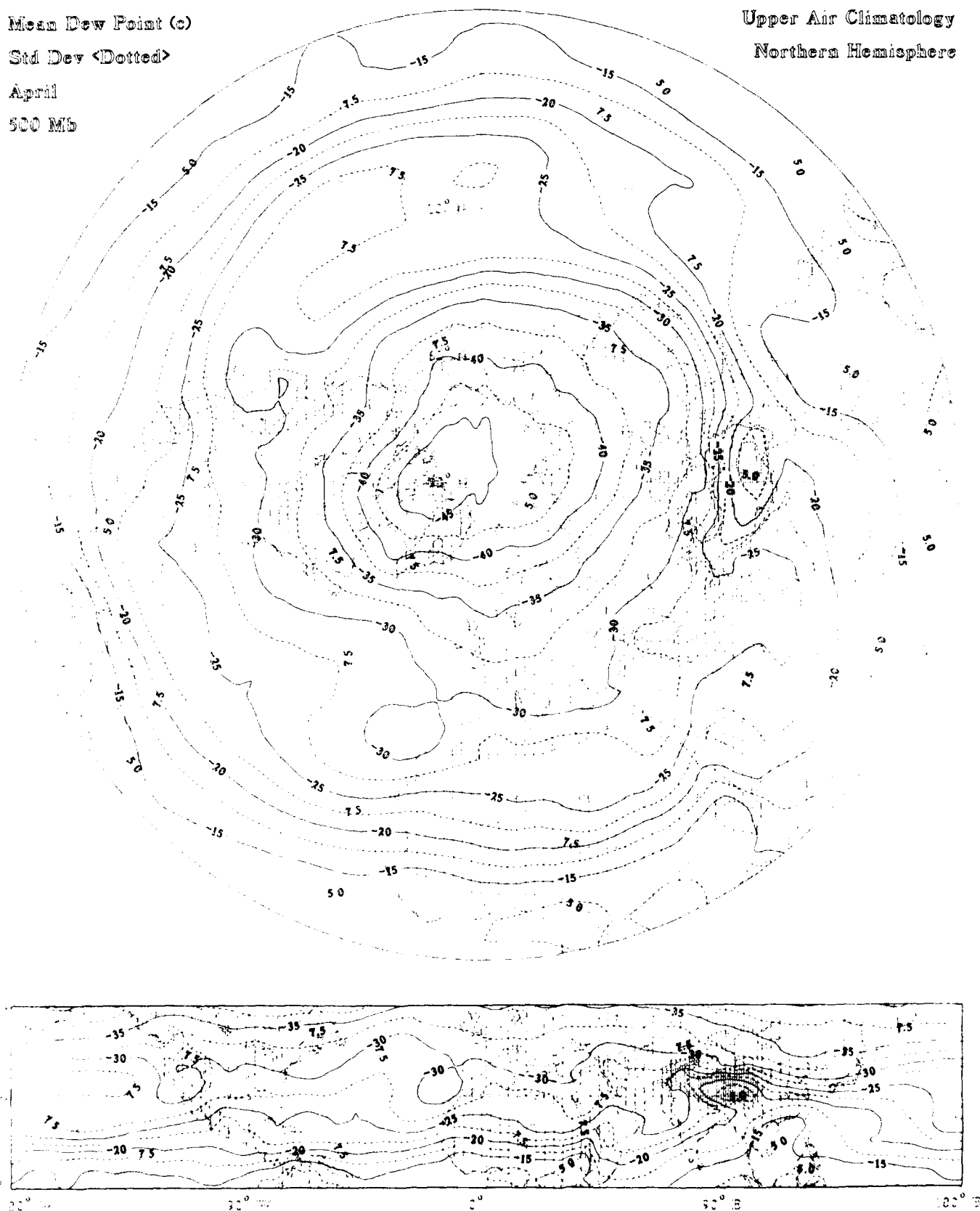
Std Dev <Dotted>

April

500 Mb

Upper Air Climatology

Northern Hemisphere



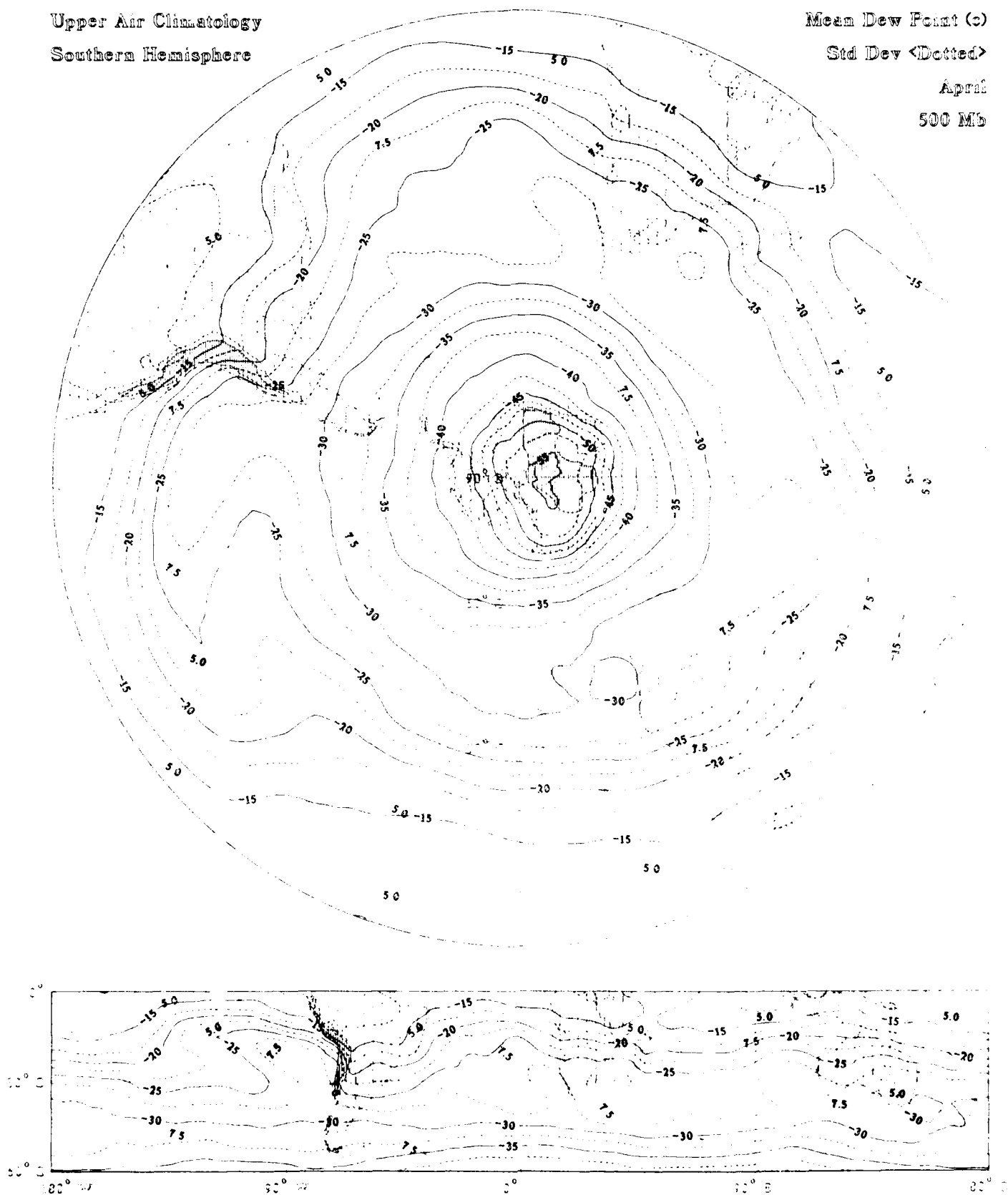
Upper Air Climatology
Southern Hemisphere

Mean Dew Point (°)

Std Dev <Dotted>

April

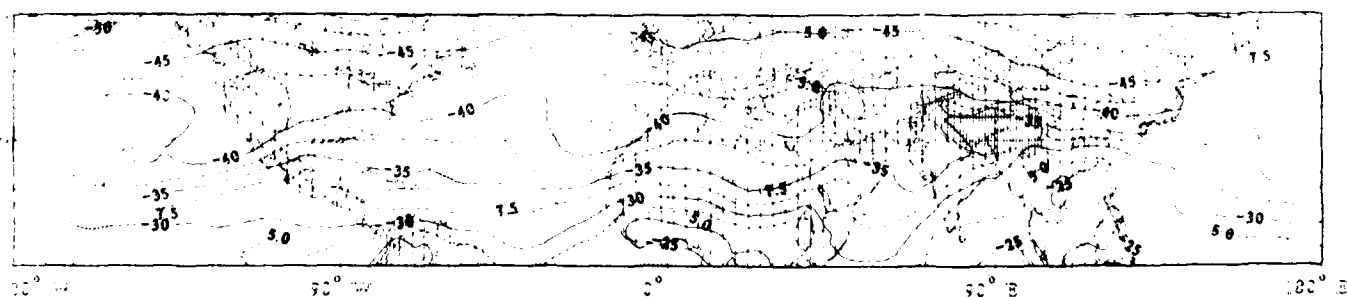
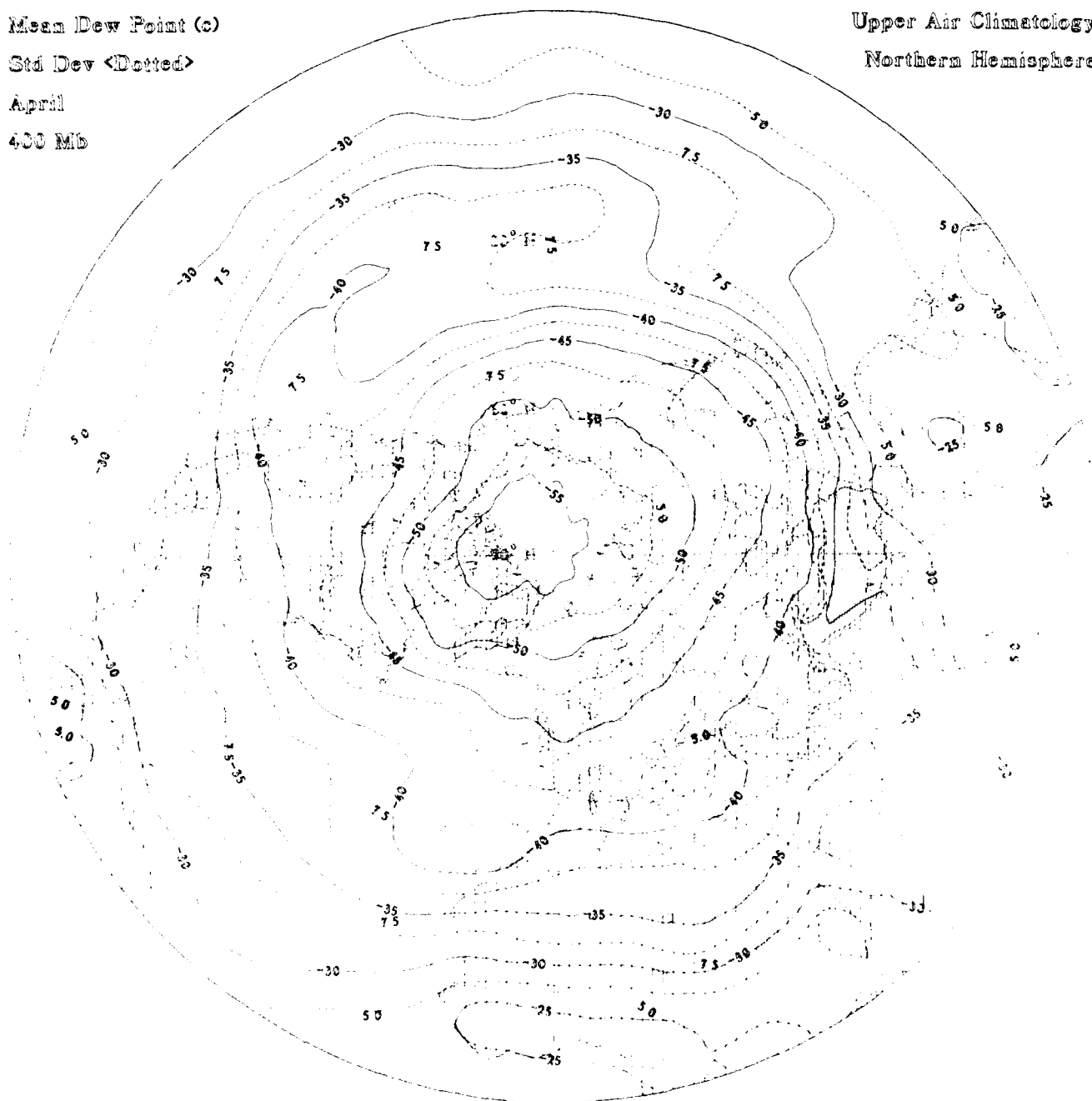
500 Mb



Upper Air Climatology

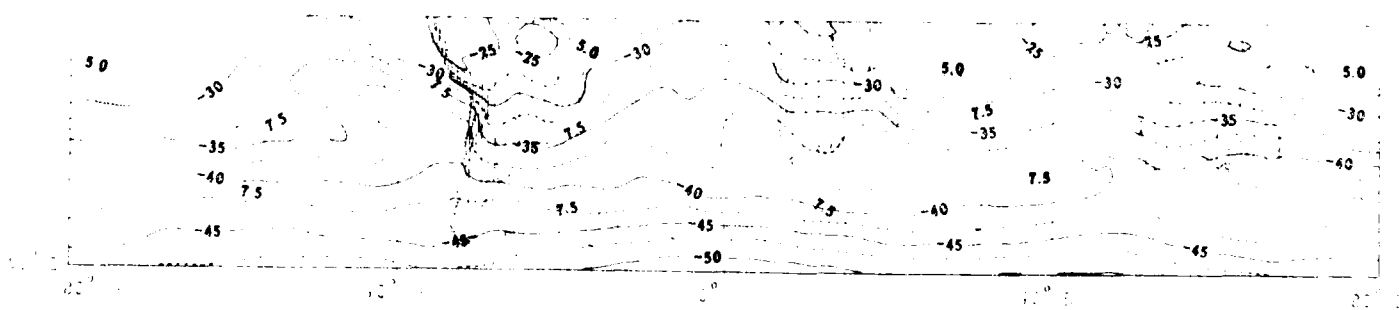
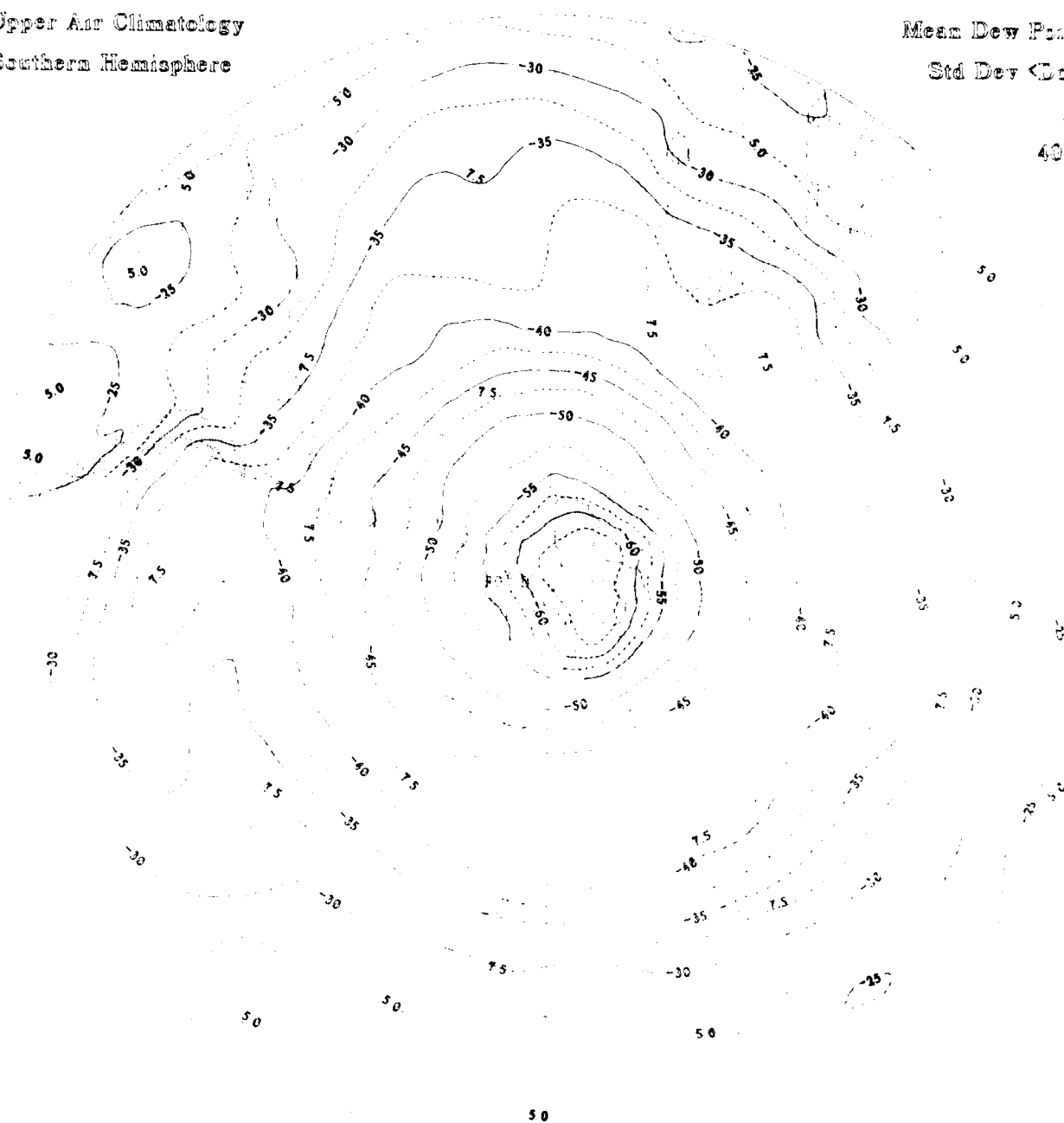
Northern Hemisphere

4.00 Mb



Upper Air Climatology
Southern Hemisphere

Mean Dew Point (°)
Std Dev <Dotted>
April
400 MB



Mean Dew Point (c)

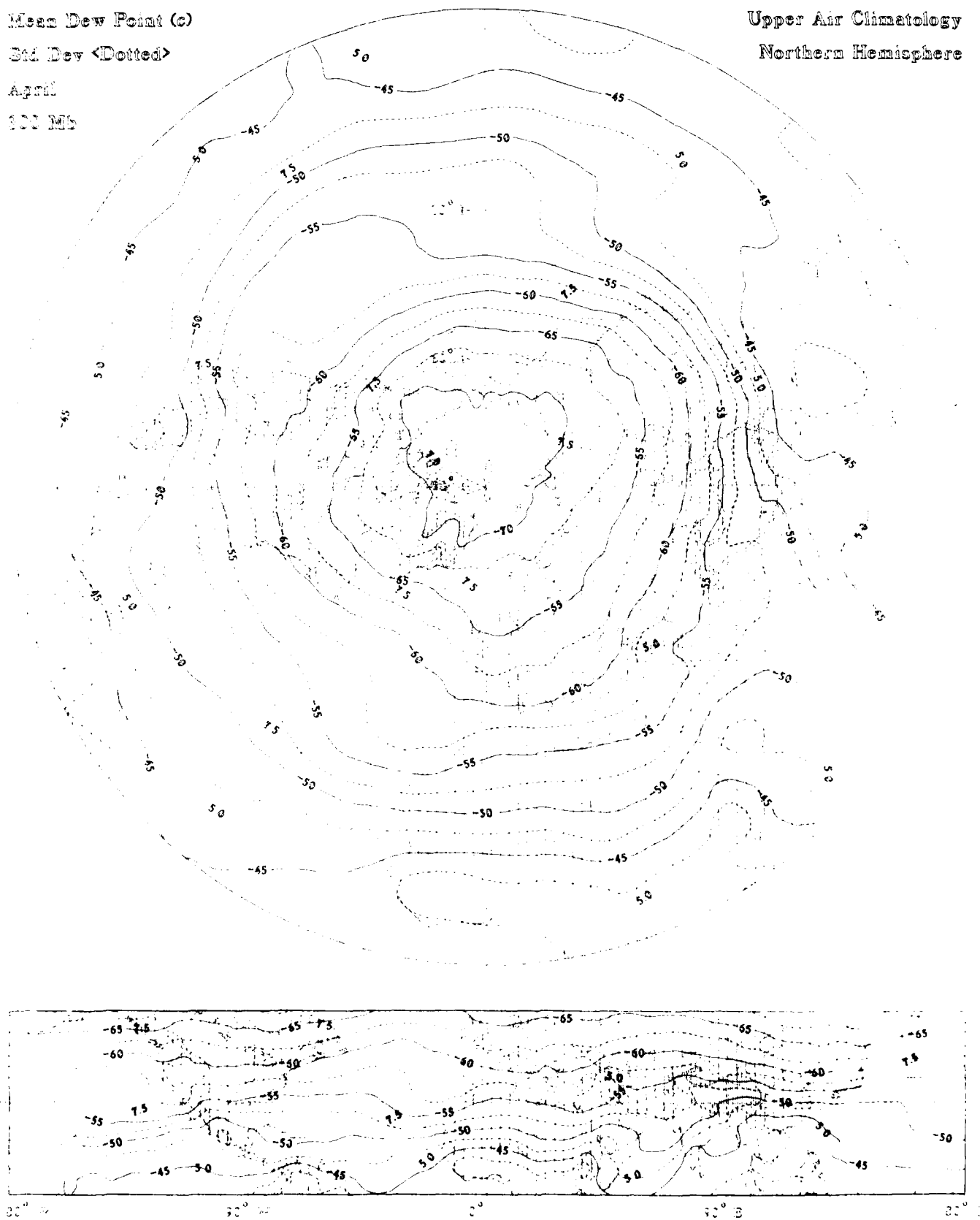
Std Dev (Dotted)

April

100 Mb

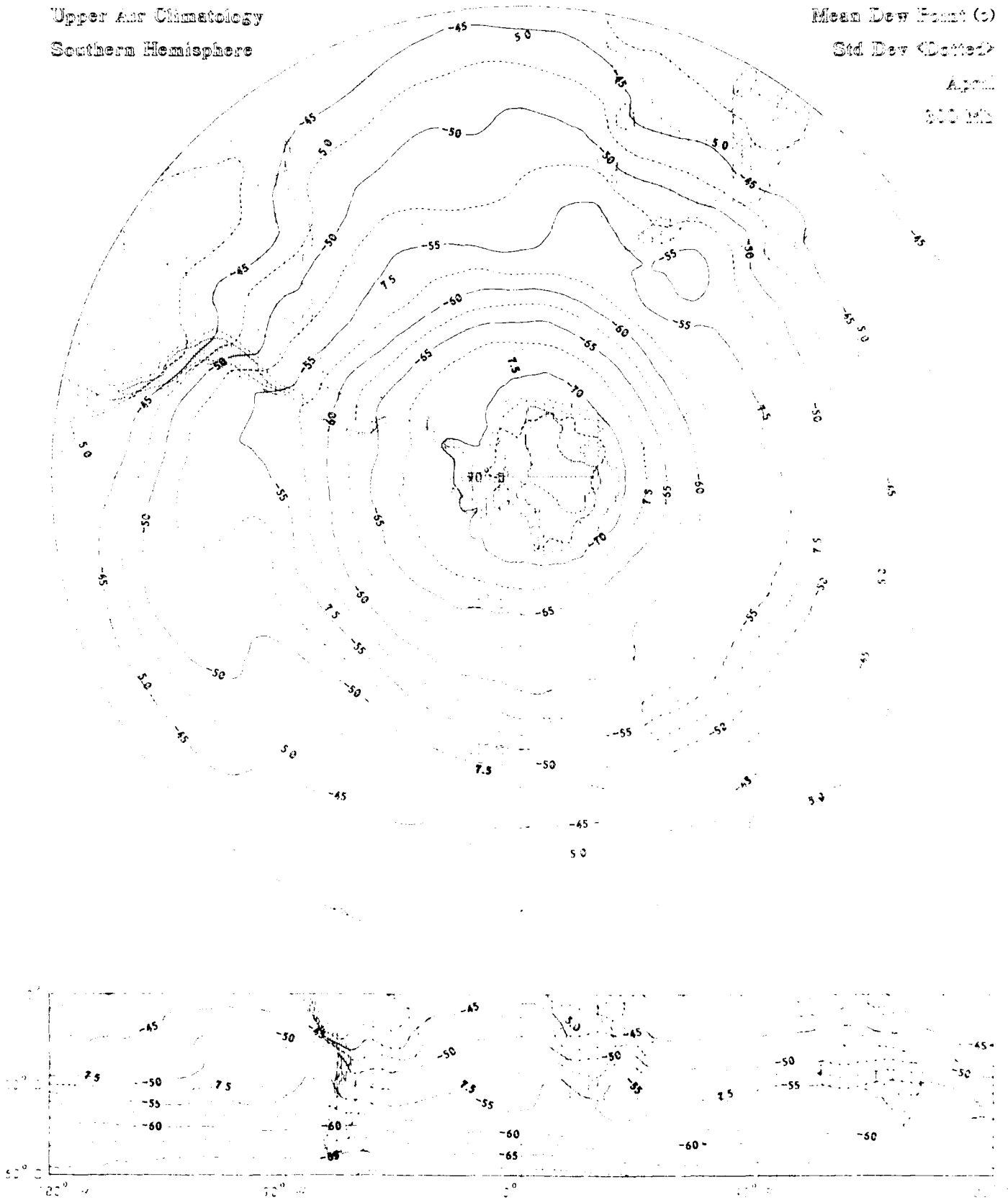
Upper Air Climatology

Northern Hemisphere



Upper Air Climatology
Southern Hemisphere

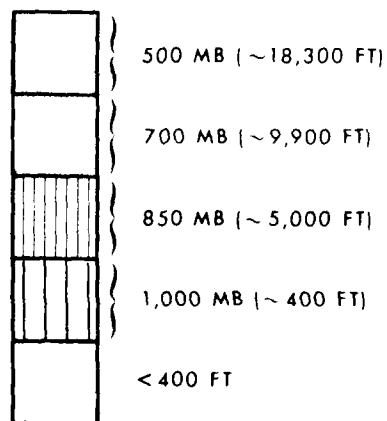
Mean Dew Point (°)
Std Dev (Dotted)
April
900 mb



DENSITY
(13 LEVELS, 1000 TO 30 MB)

- Contours of mean density (solid and dashed lines) in kilograms/cubic meter:
solids labeled, dashed intermediates unlabeled
- Density labeled interval:
 - .02 kilograms/cubic meter - 1000 MB to 400 MB
 - .01 kilograms/cubic meter - 300 MB to 200 MB
 - .006 kilograms/cubic meter - 150 MB to 30 MB
- Contours of standard deviation of density (dotted lines) in kilograms/cubic meter
- Standard deviation of density labeled interval:
 - .01 kilograms/cubic meter - 1000 MB to 400 MB
 - .005 kilograms/cubic meter - 300 MB to 200 MB
 - .003 kilograms/cubic meter - 150 MB to 30 MB
- Contours blanked for geographic areas with elevations exceeding specified geopotential heights

ELEVATION SCALE



Mean Density (kg/m³)

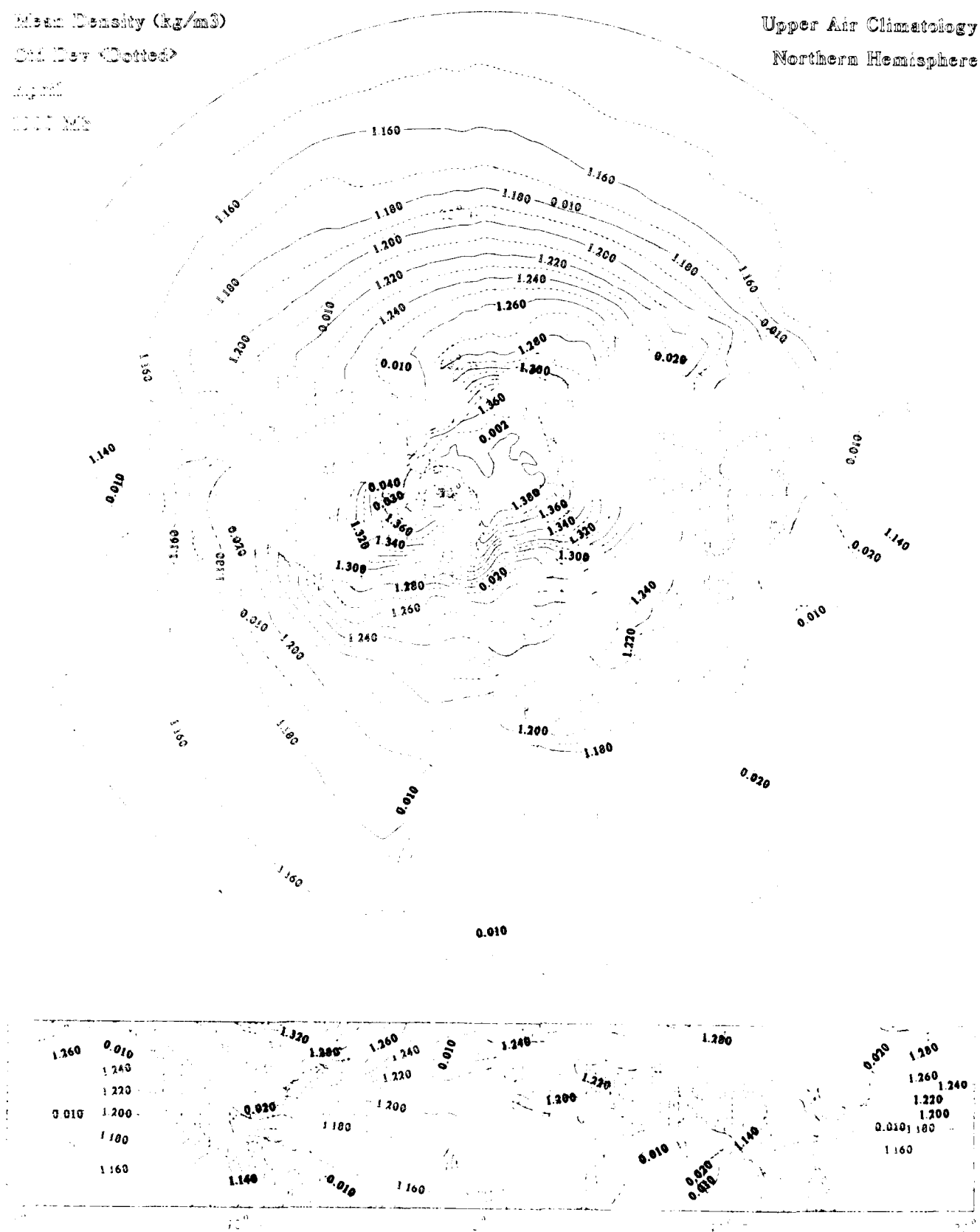
Std Dev (Dotted)

April

1977-1978

Upper Air Climatology

Northern Hemisphere



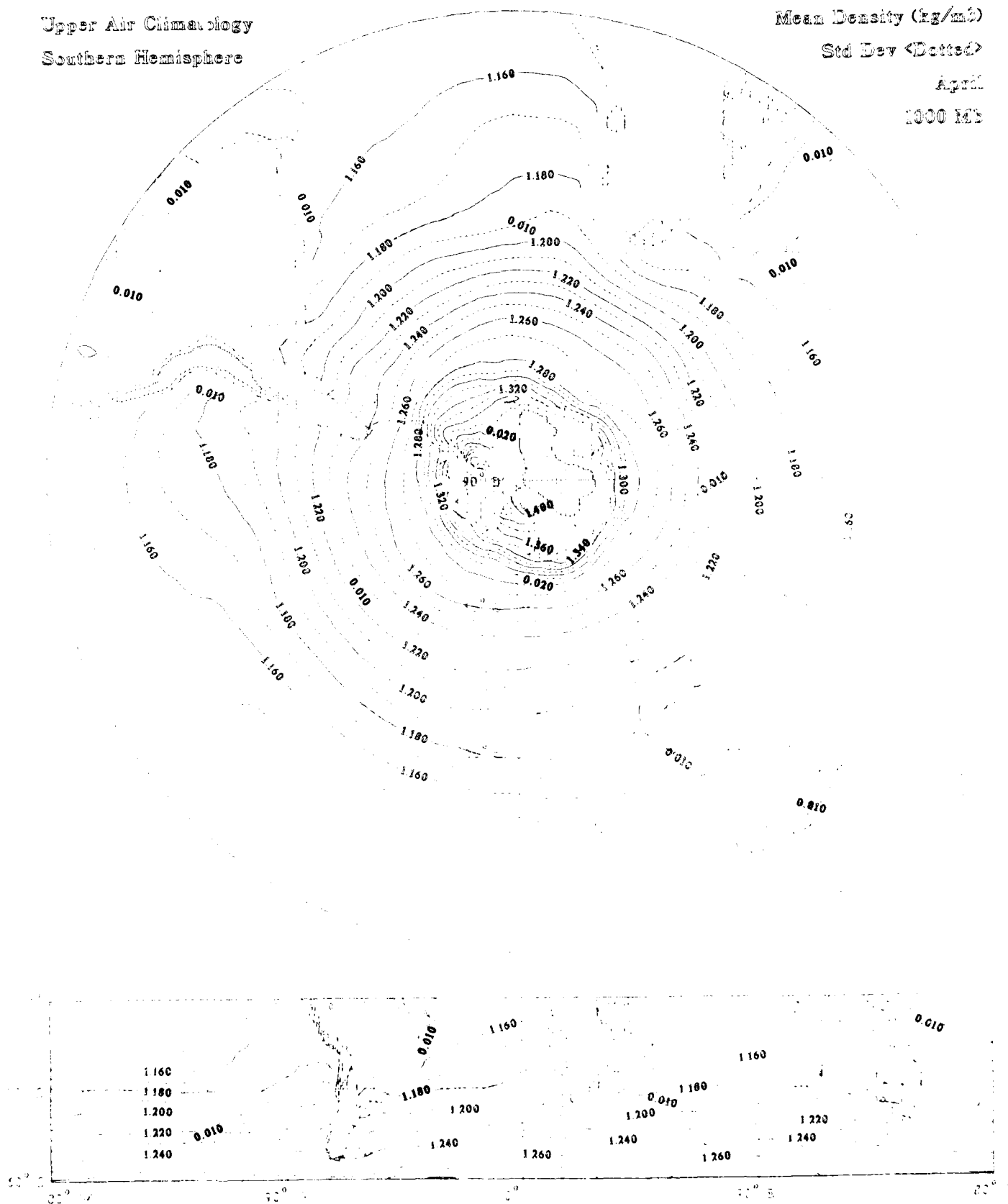
Upper Air Climatology
Southern Hemisphere

Mean Density (kg/m³)

Std Dev (Dotted)

April

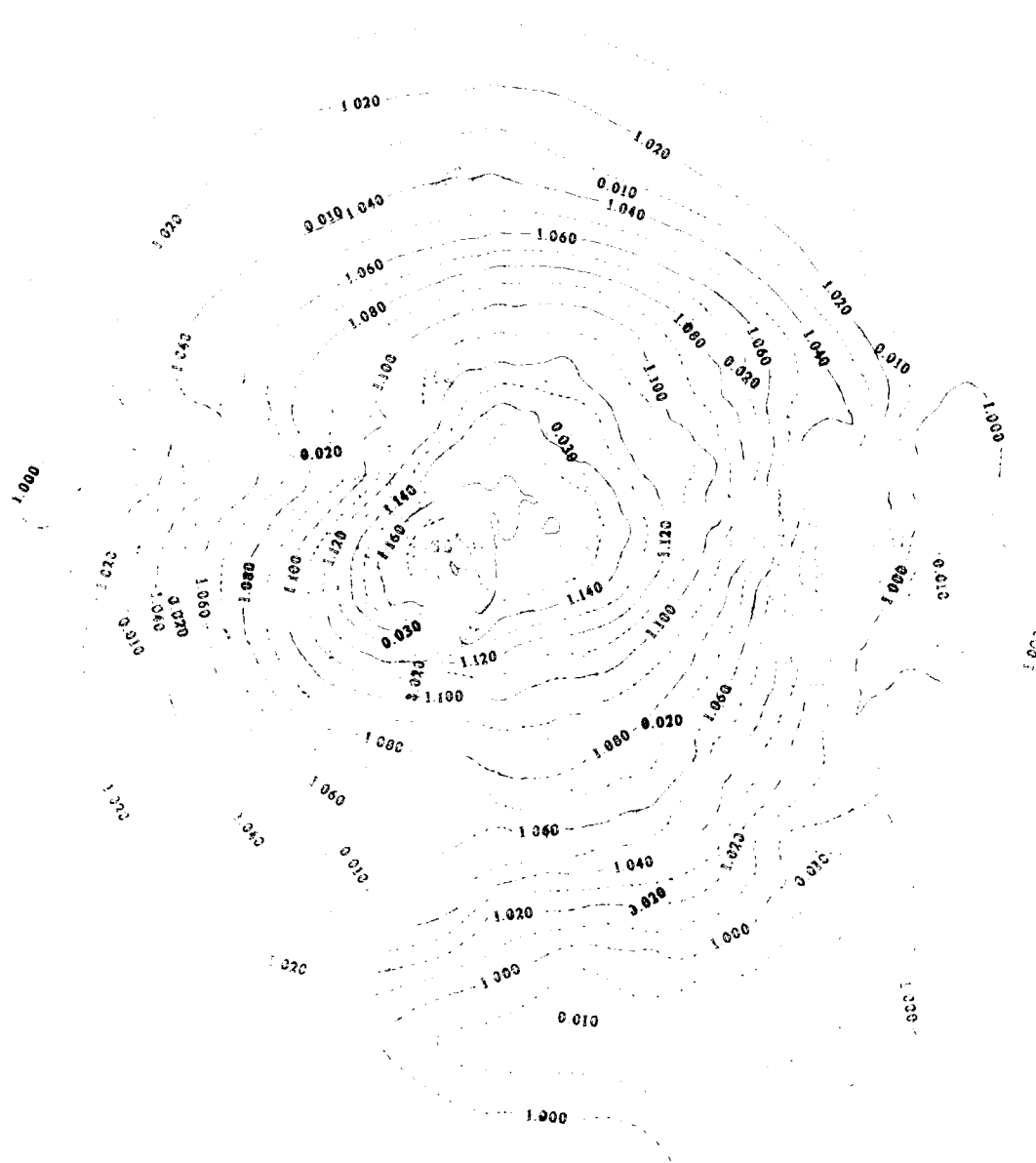
1000 MB



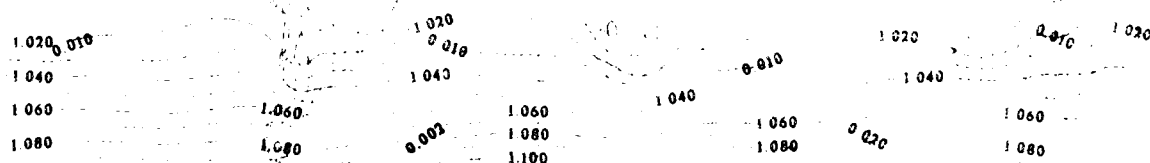
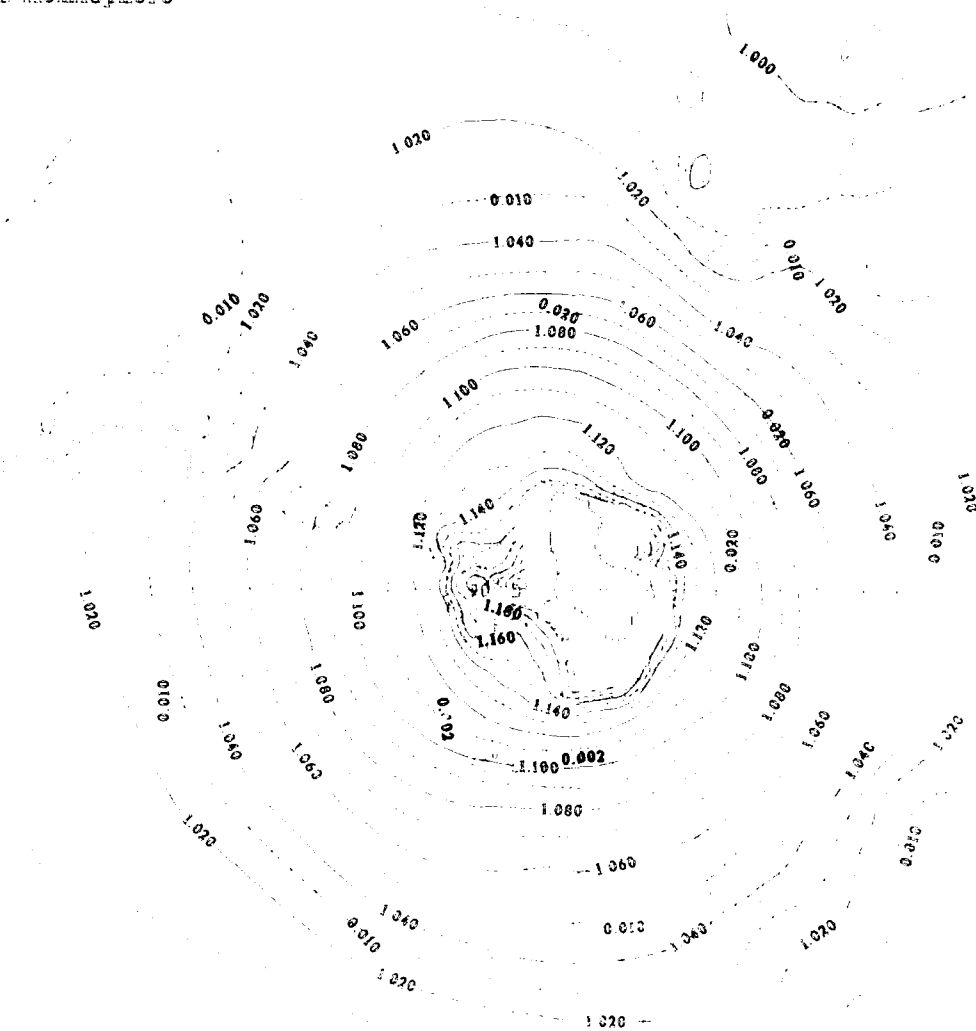
Upper Air Climatology

Northern Hemisphere

200 2005



350 MB



Mean Density (kg/m³)

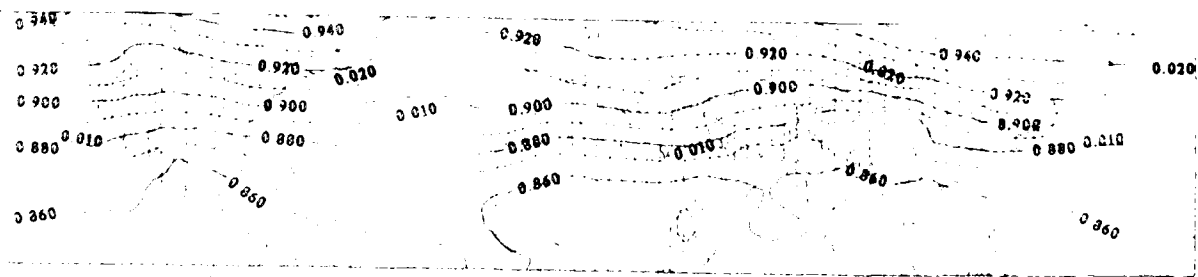
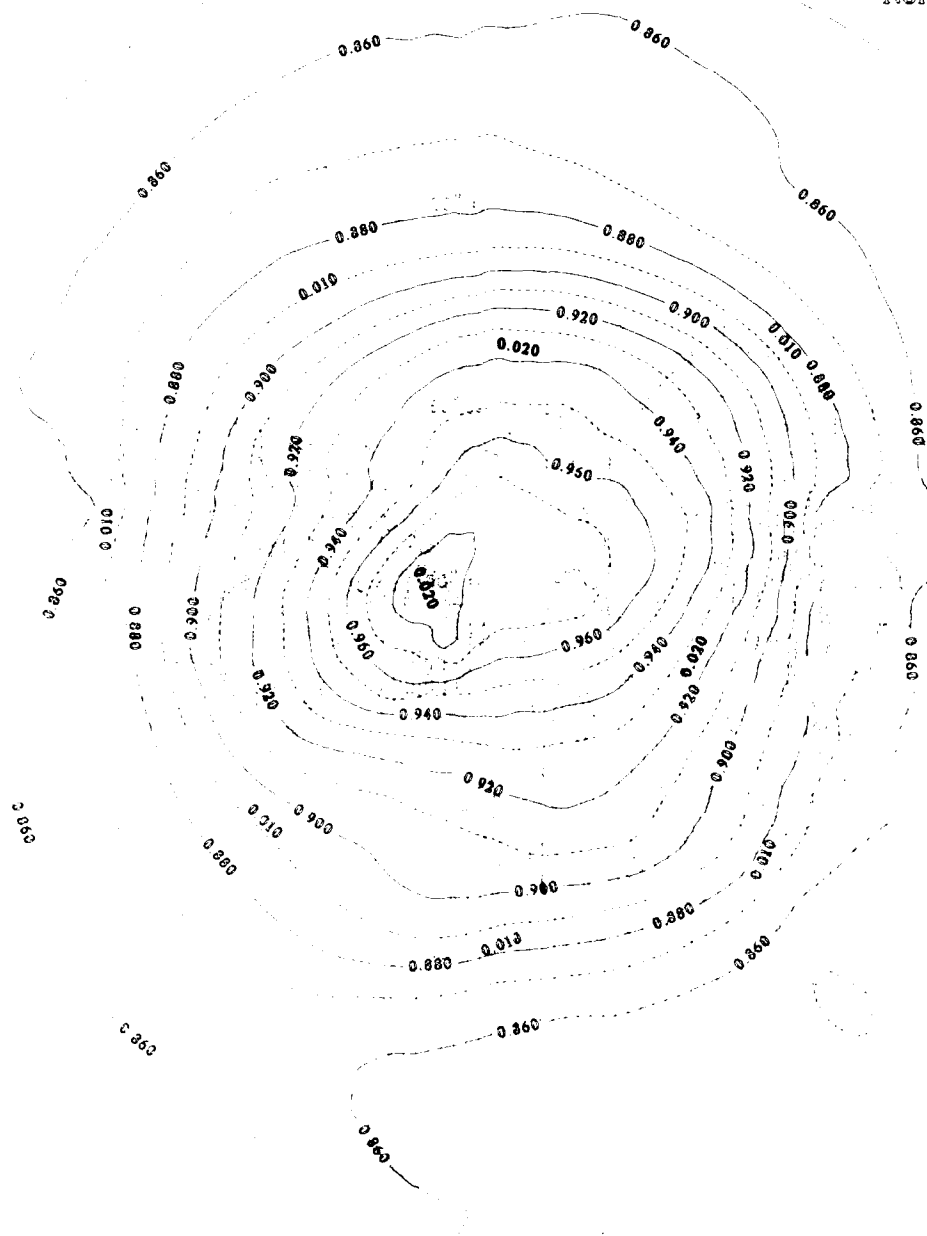
Std Dev (Dotted)

April

1977-1978

Upper Air Climatology

Northern Hemisphere



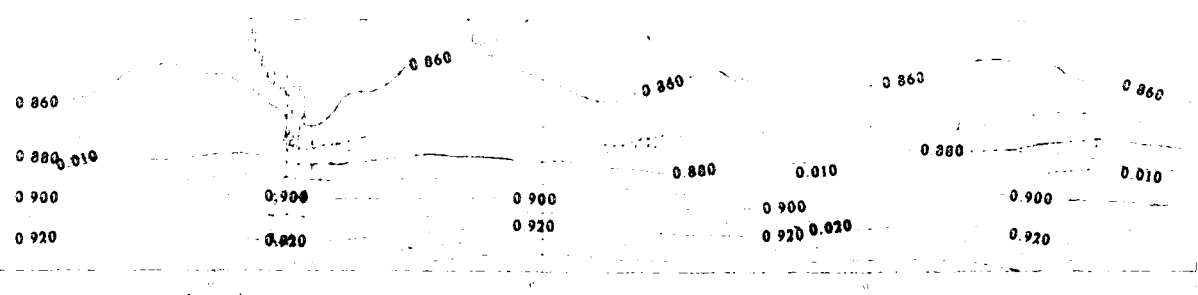
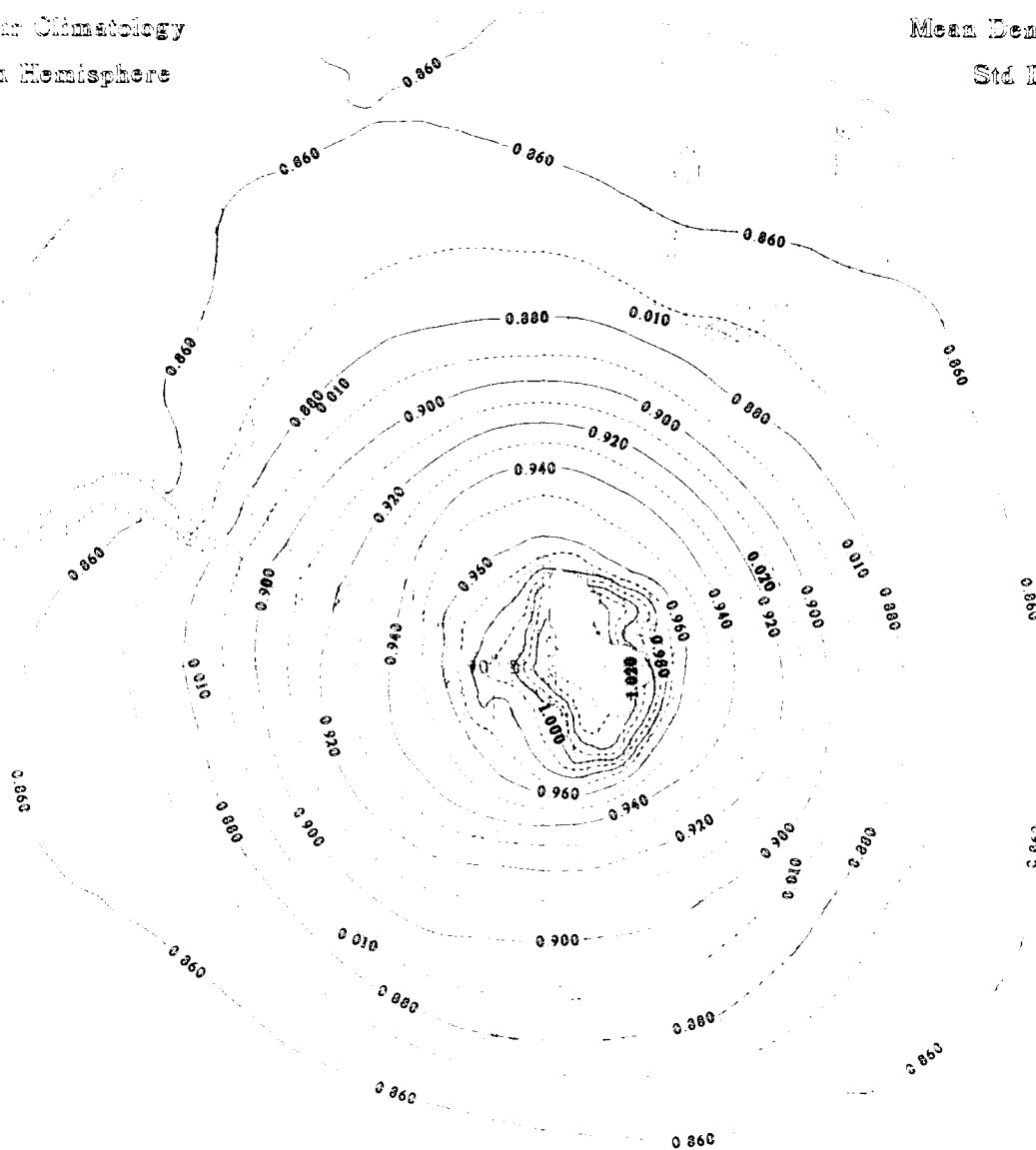
Upper Air Climatology
Southern Hemisphere

Mean Density (kg/m^3)

Std Dev (Dotted)

April

700 MB



Mean Density (kg/m³)

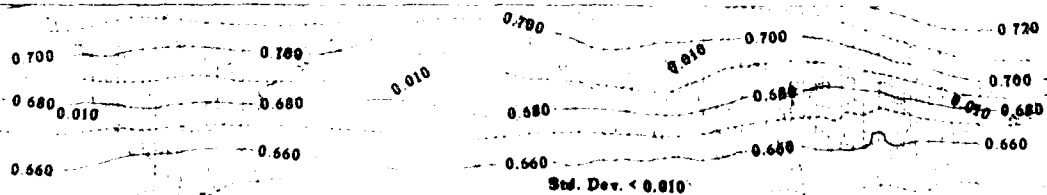
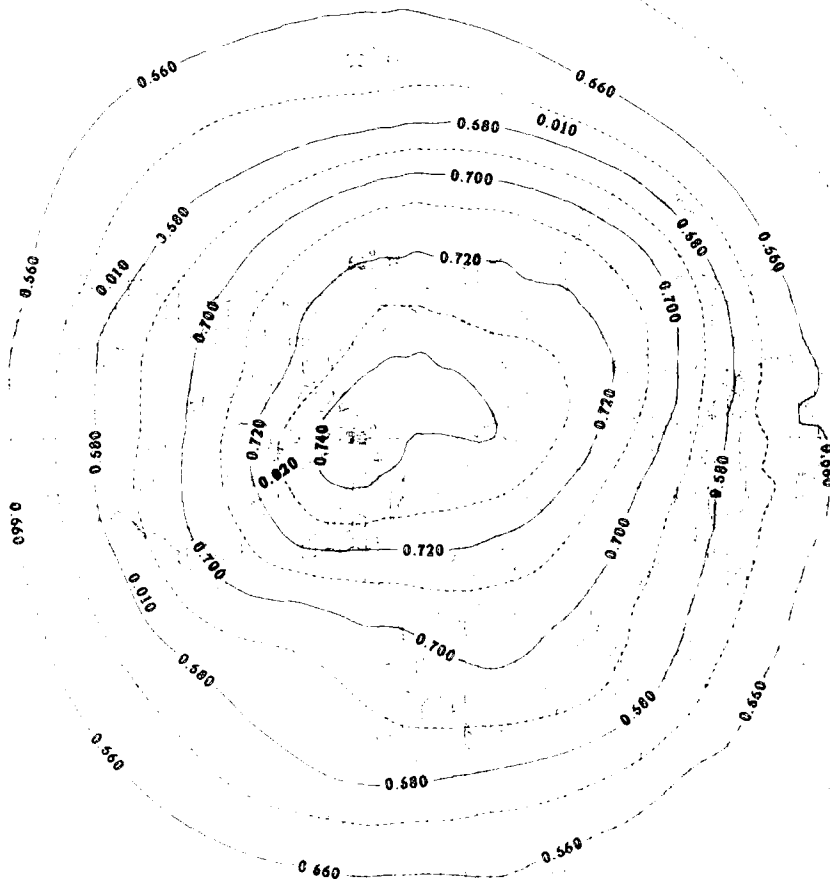
Std Dev <Dotted>

April

500 MB

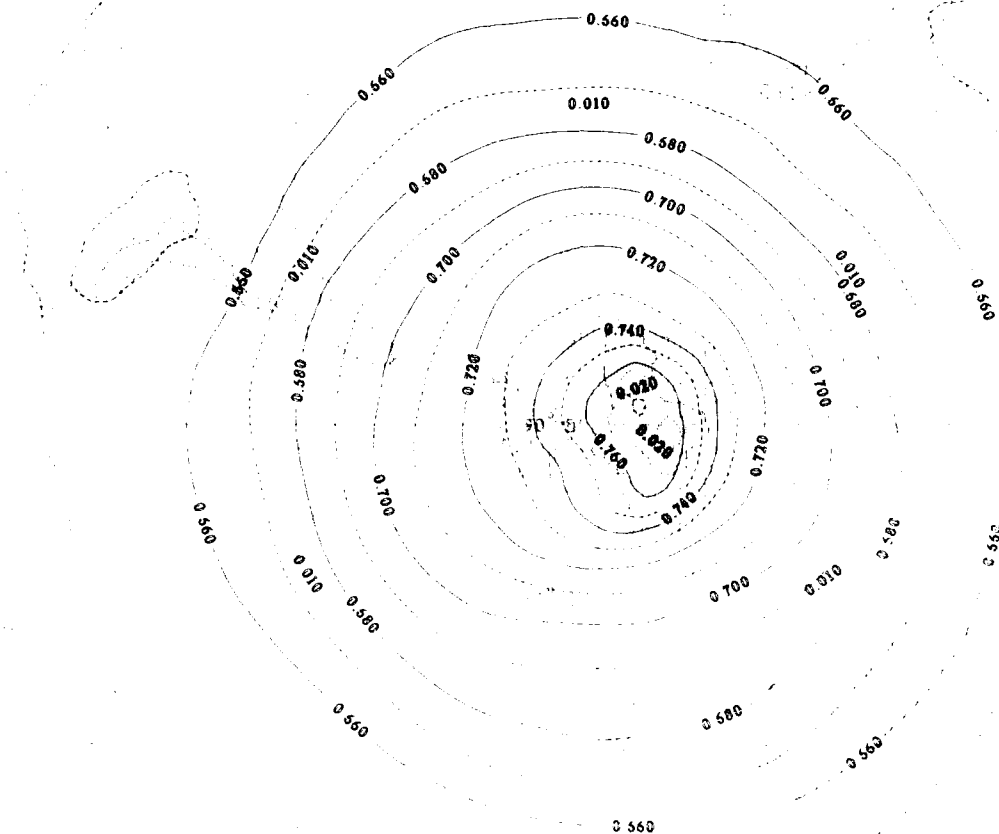
Upper Air Climatology

Northern Hemisphere



Upper Air Climatology
Southern Hemisphere

Mean Density (kg/m³)
Std Dev <Dotted>
April
500 MB



0.560

0.580

0.700

0.560

0.580

0.700

0.010

Std. Dev. < 0.010

0.560

0.580

0.700

0.010

0.560

0.580

0.700

0.560

0.580

0.700

Mean Density (kg/m³)

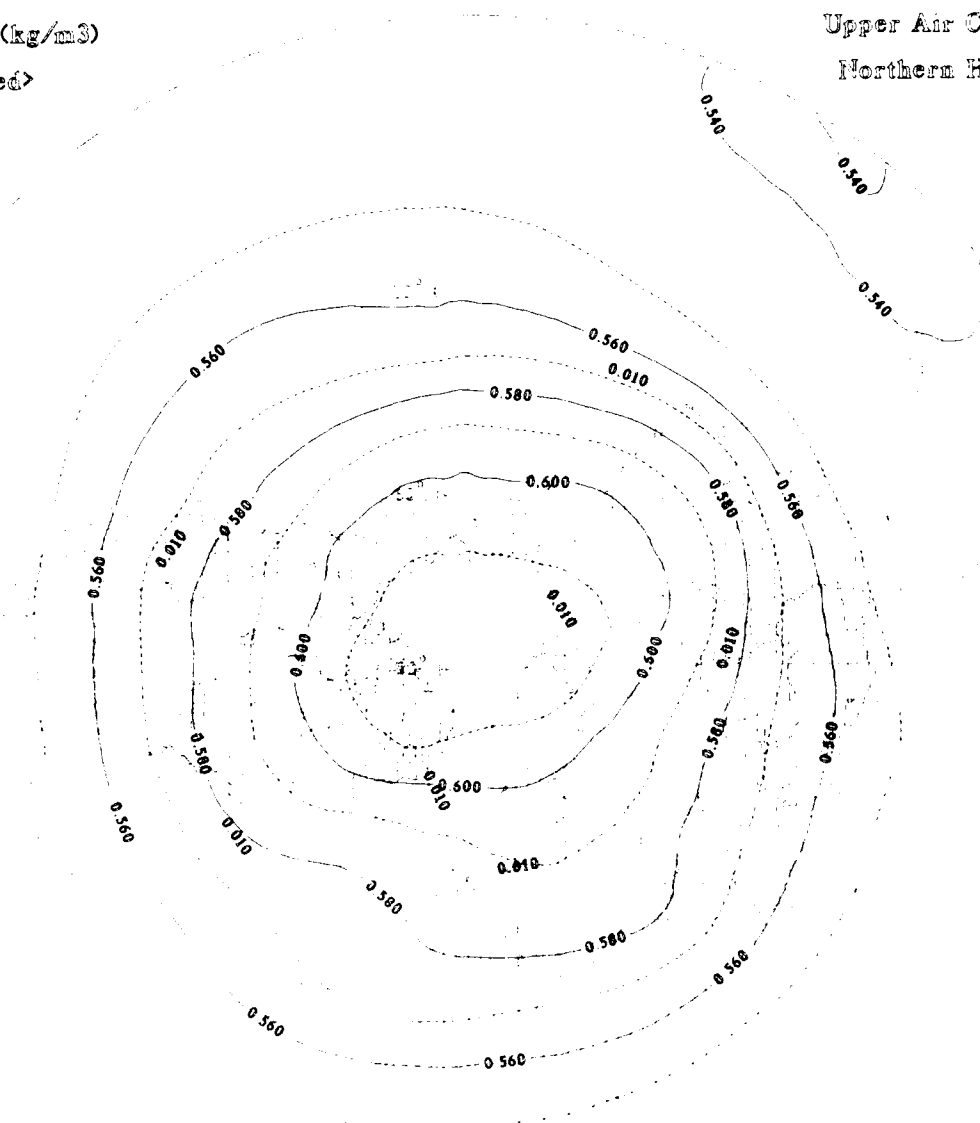
Std Dev <Dotted>

April

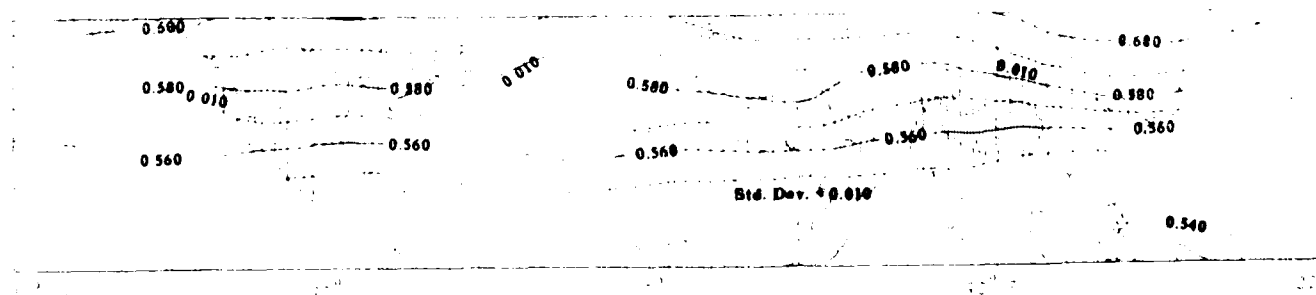
400 Mb

Upper Air Climatology

Northern Hemisphere



Std. Dev. < 0.010



Std. Dev. < 0.010

400 MB



Mean Density (kg/m³)

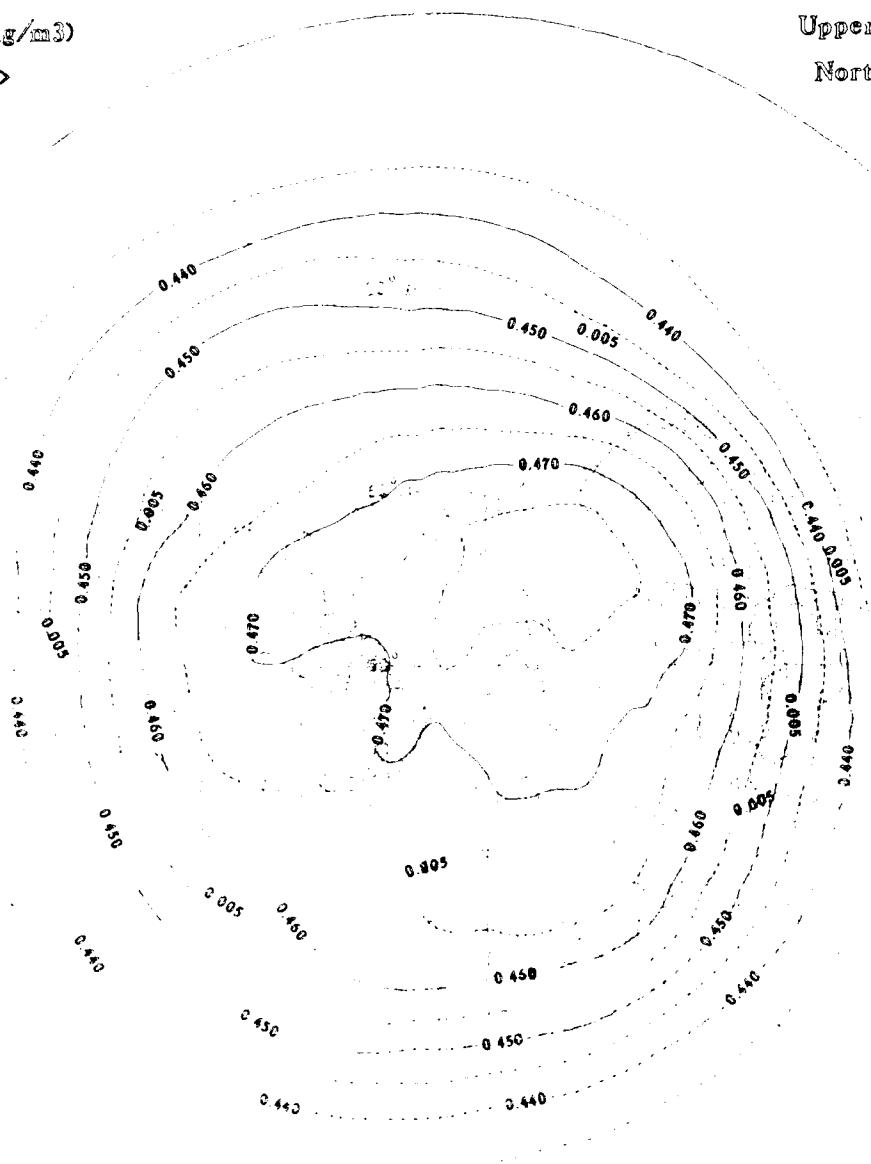
Std Dev <Dotted>

April

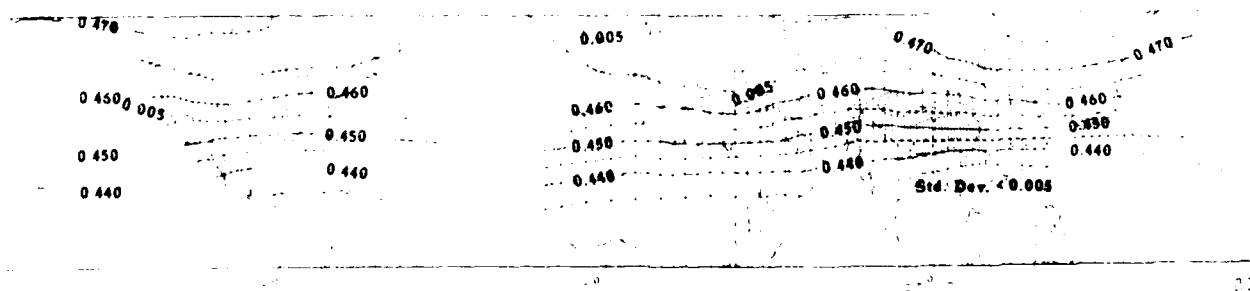
300 MB

Upper Air Climatology

Northern Hemisphere



Std. Dev. <0.005



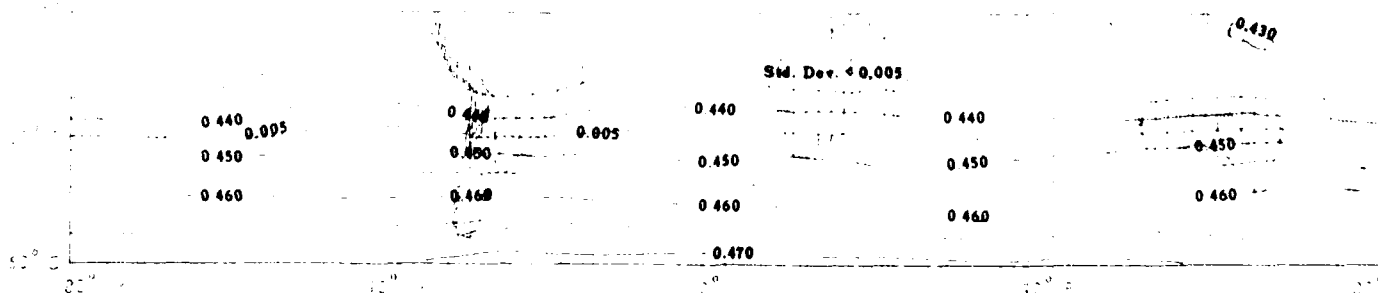
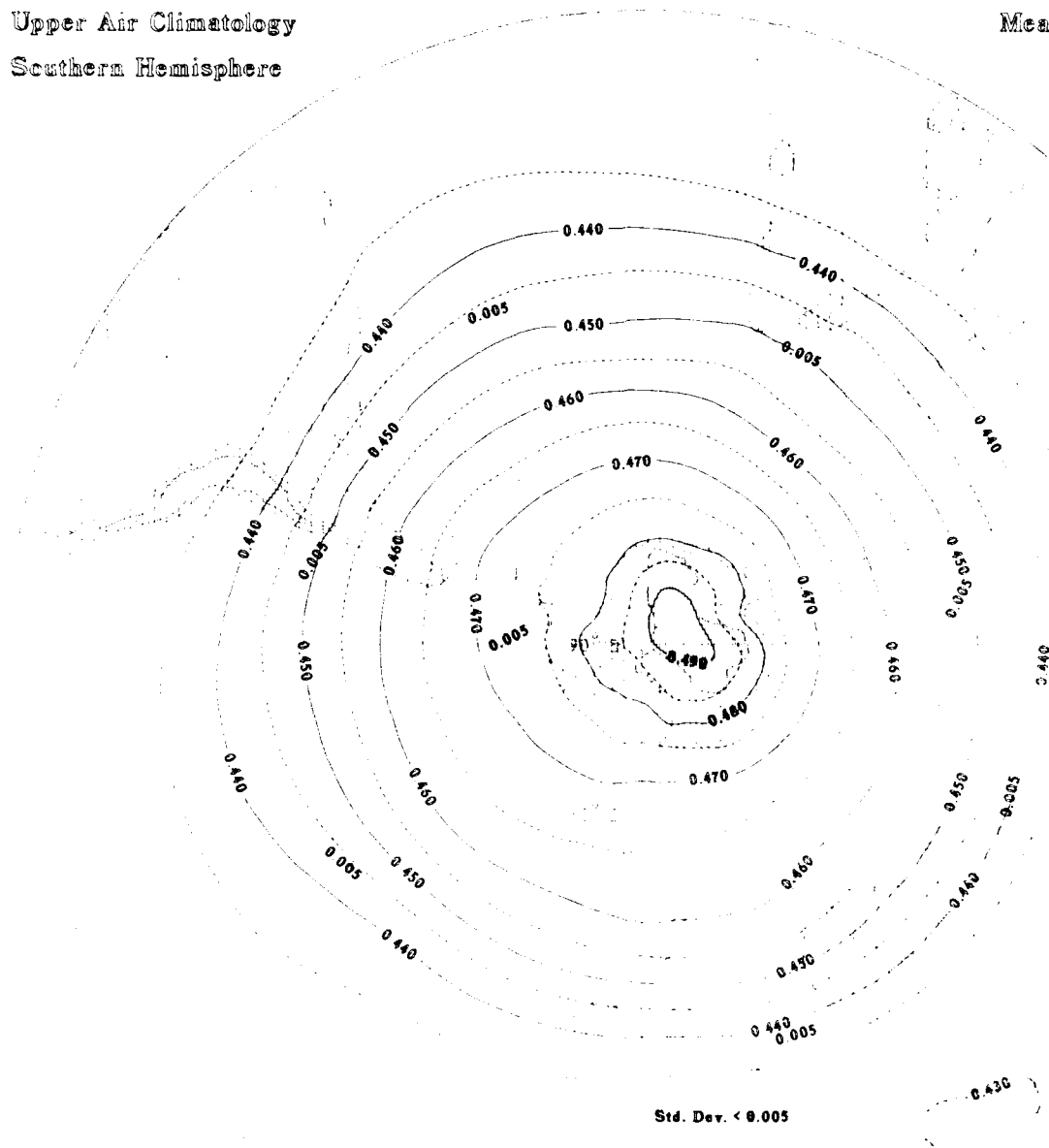
Upper Air Climatology
Southern Hemisphere

Mean Density (kg/m³)

Std Dev <Dotted>

April

300 MB



Mean Density (kg/m³)

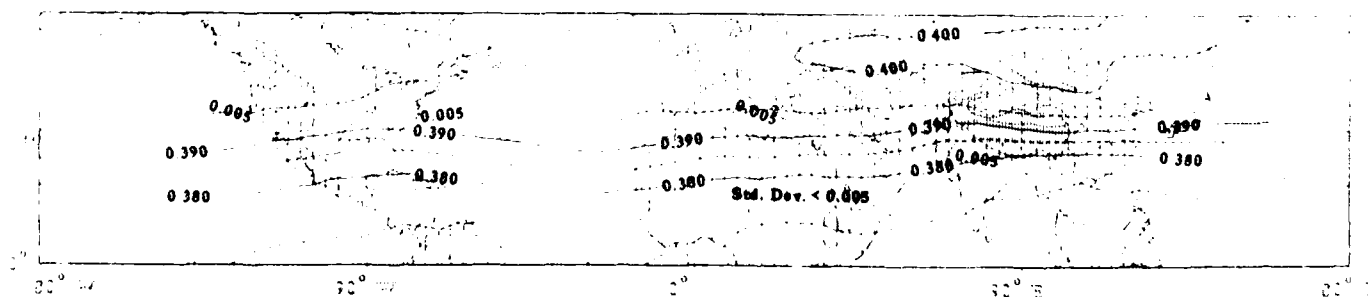
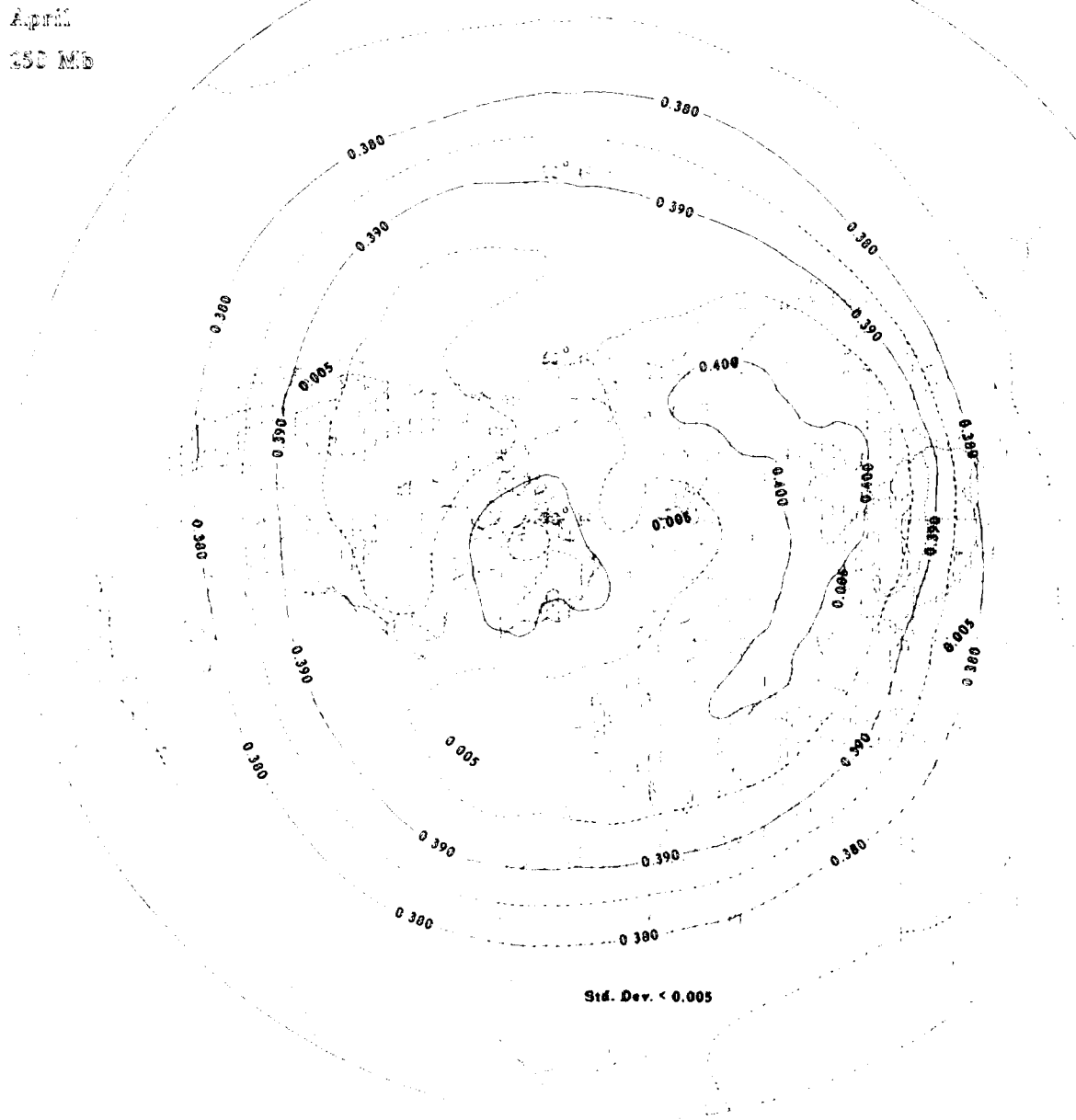
Std Dev <Dotted>

April

350 Mb

Upper Air Climatology

Northern Hemisphere



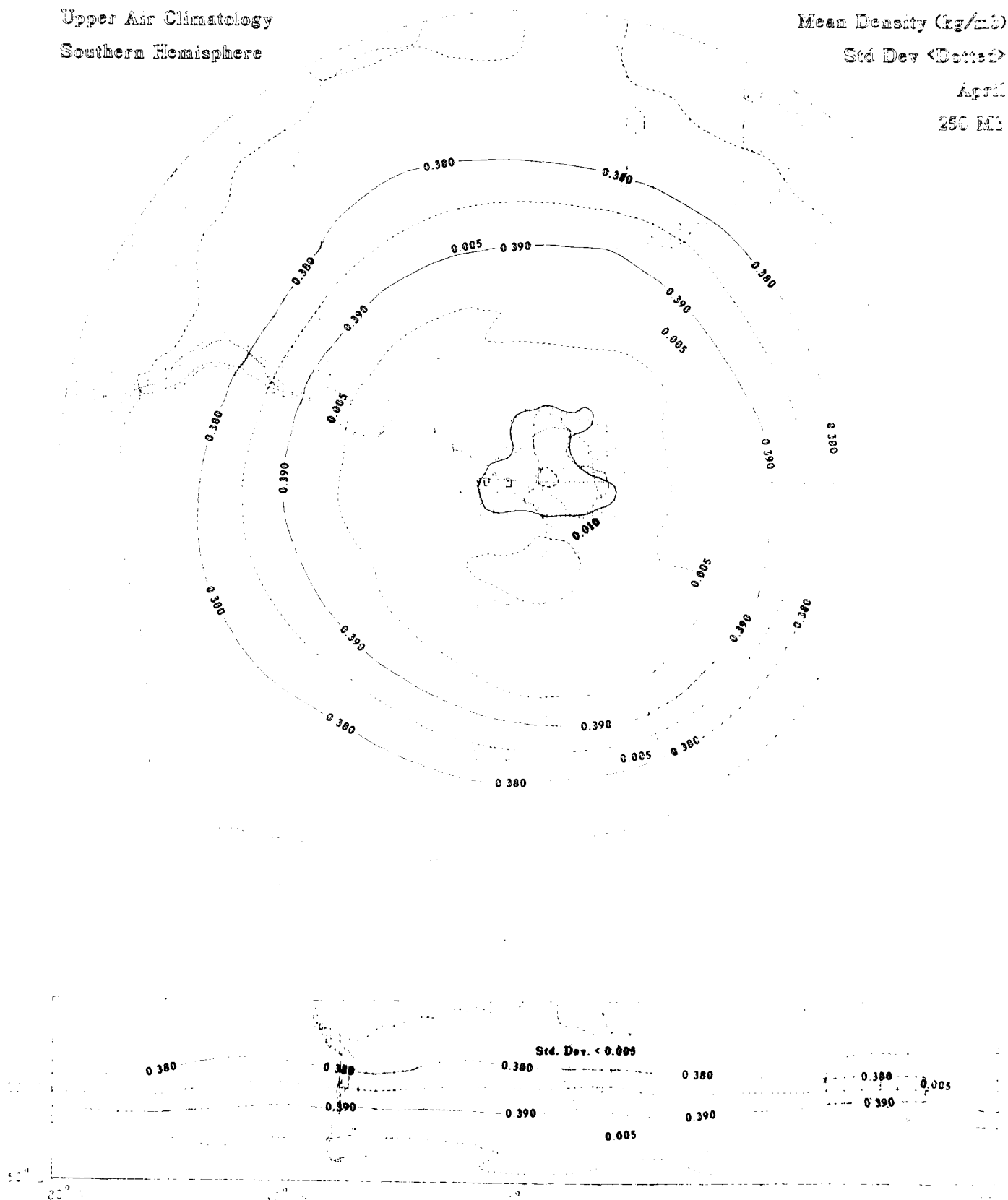
Upper Air Climatology
Southern Hemisphere

Mean Density (kg/m³)

Std Dev <Dotted>

April

250 M2



Mean Density (kg/m³)

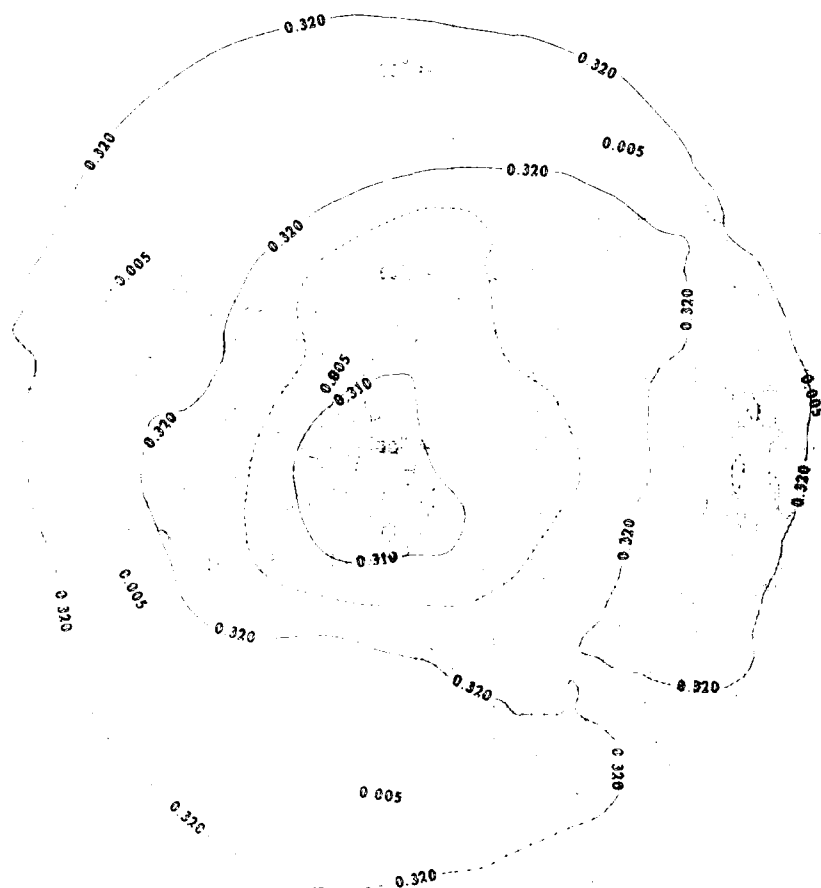
Std. Dev. <Dotted>

April

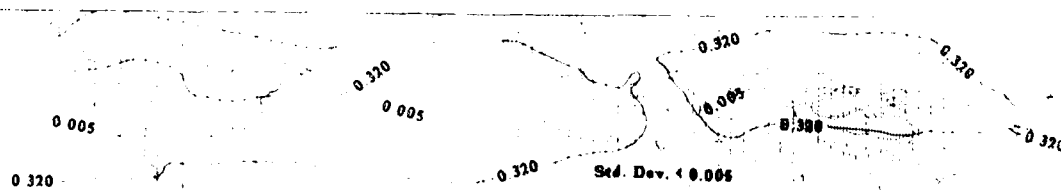
200 Mb

Upper Air Climatology

Northern Hemisphere



Std. Dev. < 0.005



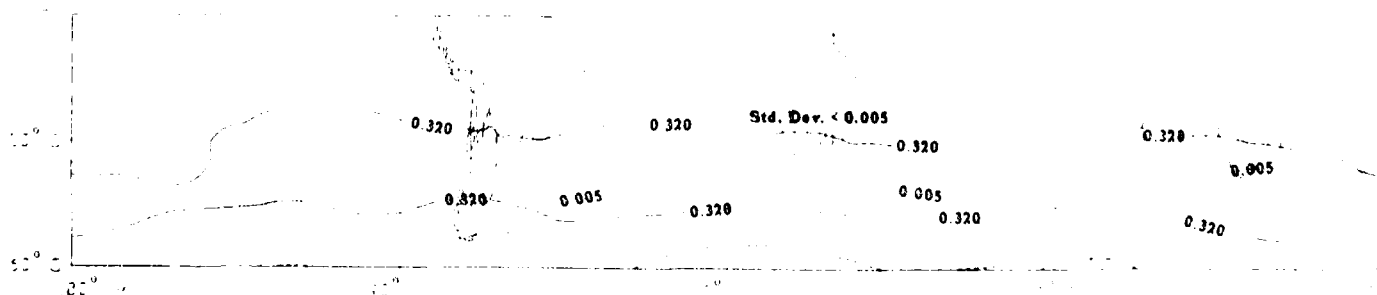
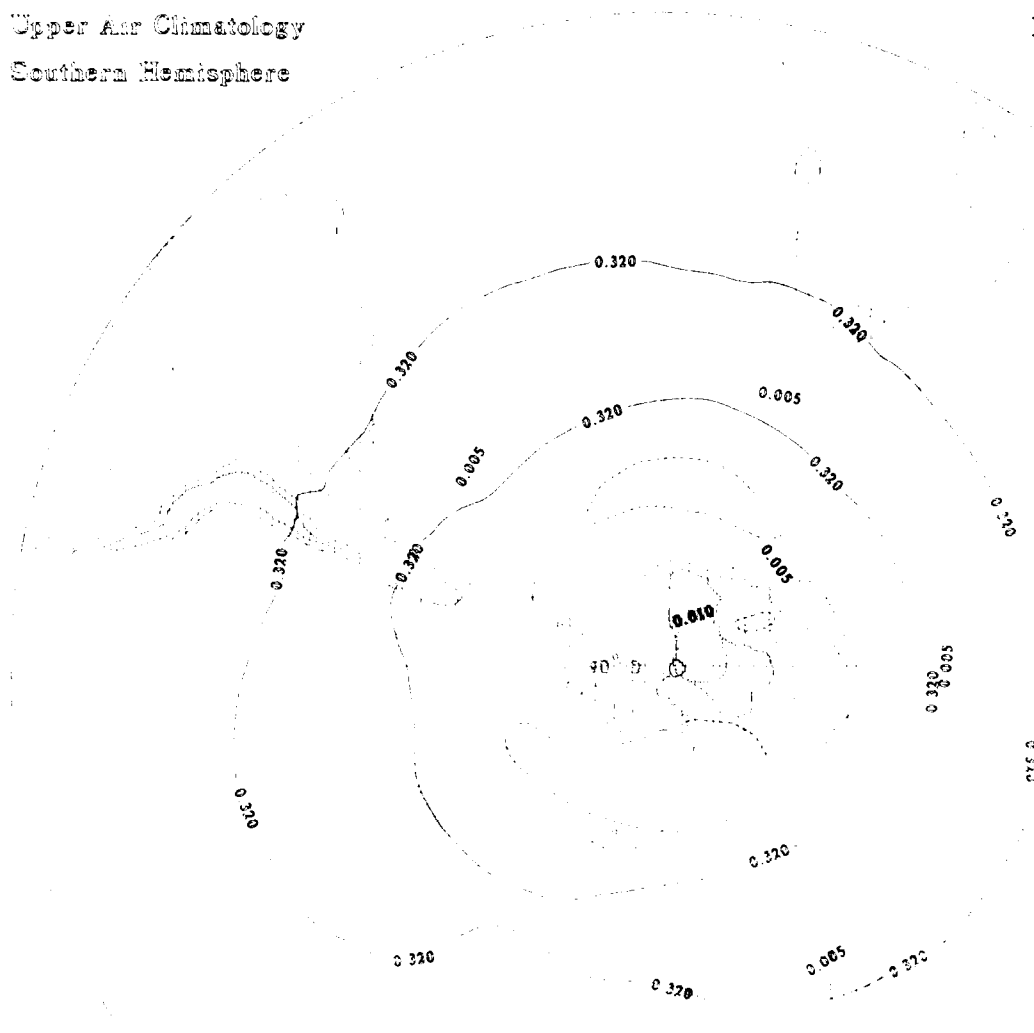
Upper Air Climatology
Southern Hemisphere

Mean Density (kg/m^3)

Std Dev. < 0.005

April

1971-1972



Mean Density (kg/m³)

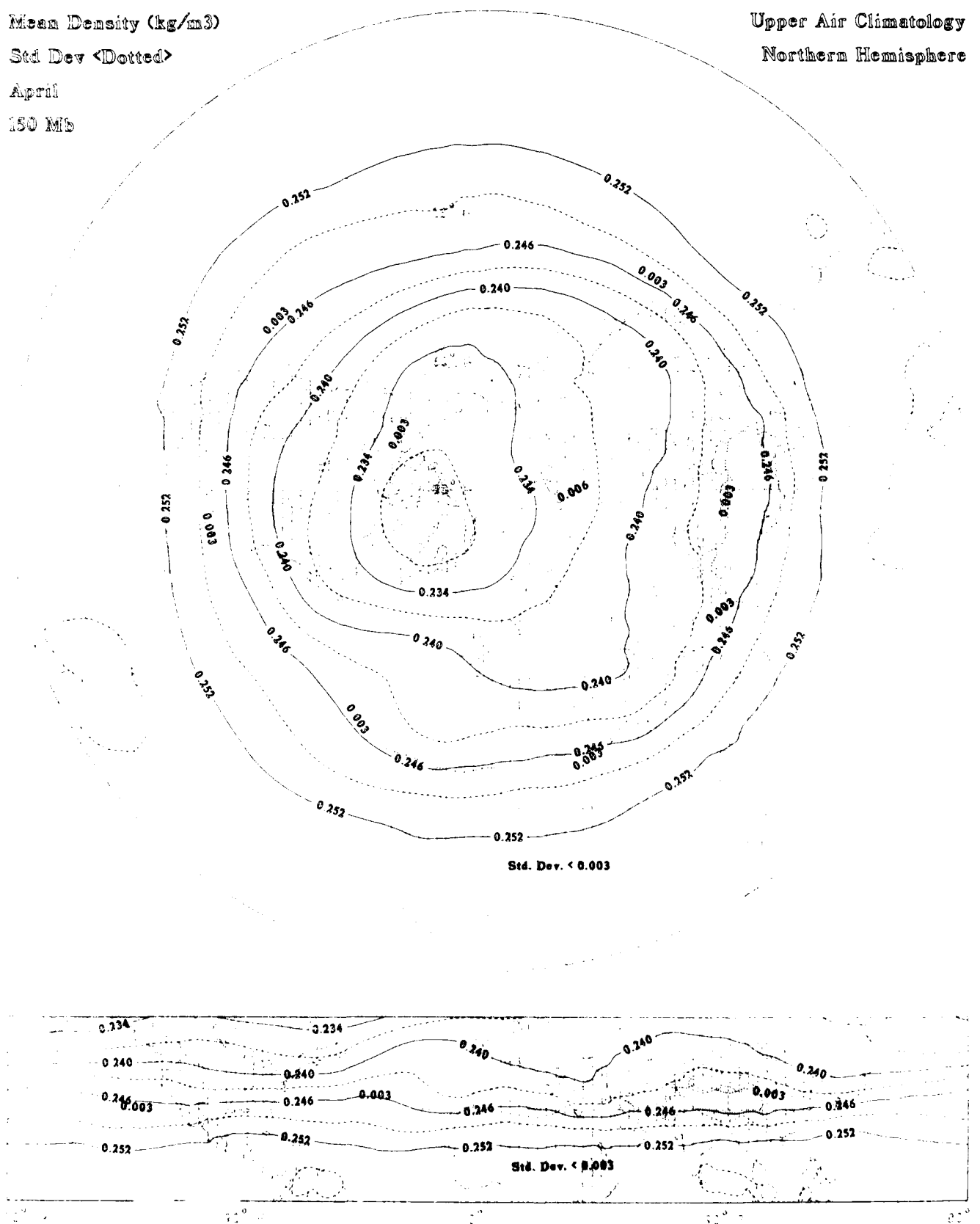
Std Dev <Dotted>

April

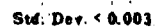
150 Mb

Upper Air Climatology

Northern Hemisphere



150 Mb



Mean Density (kg/m³)

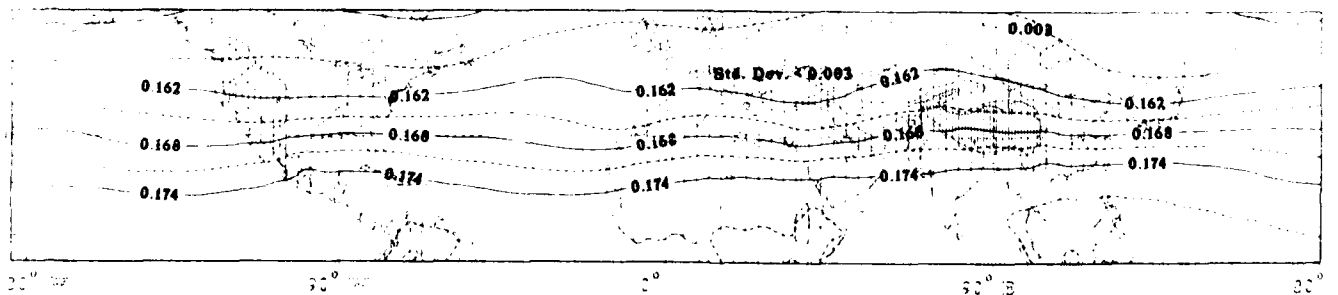
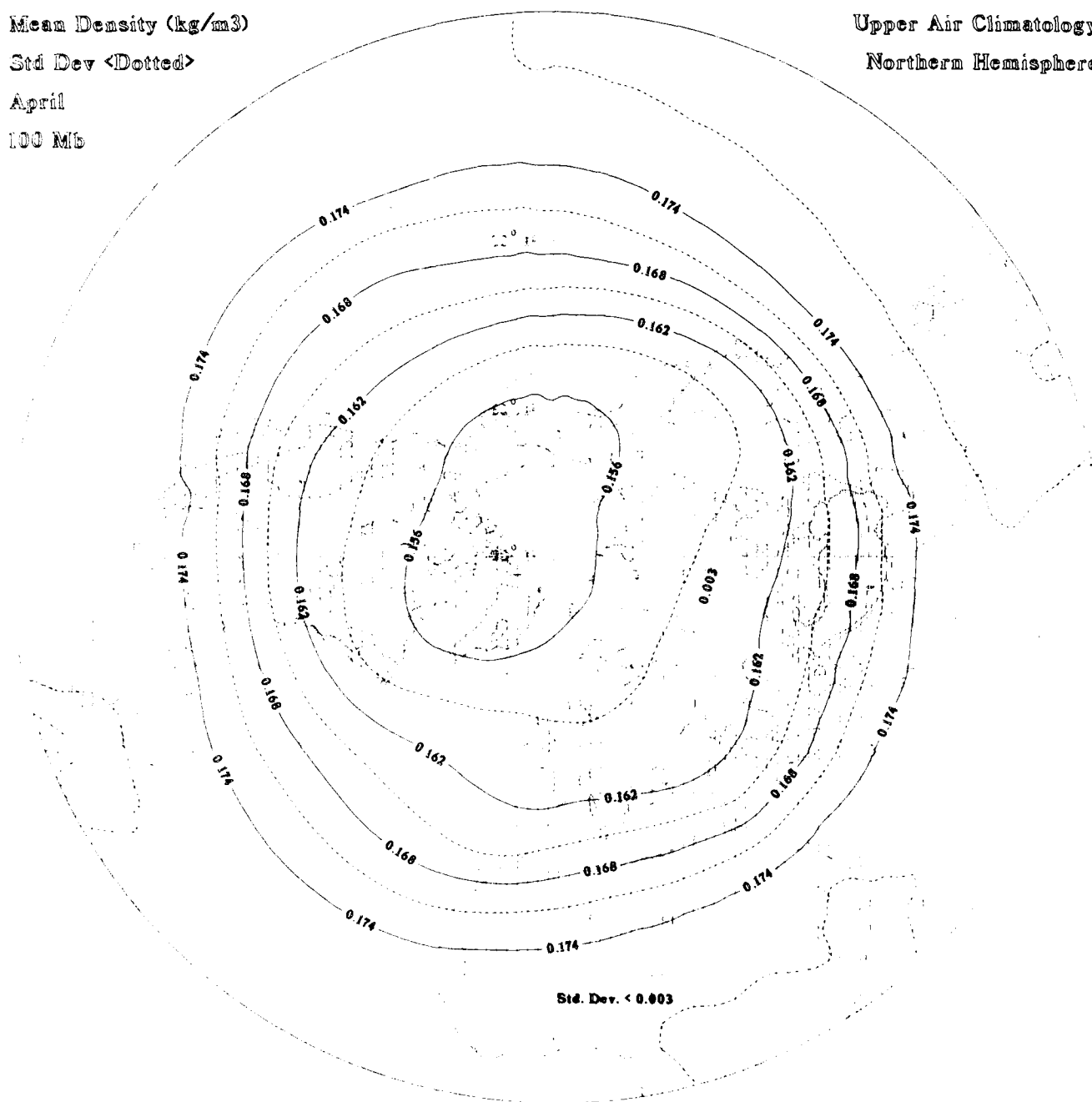
Std Dev <Dotted>

April

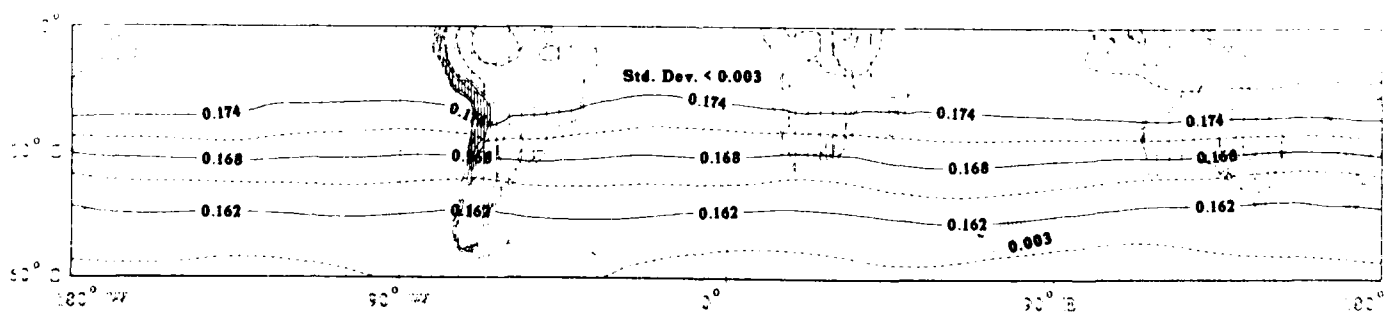
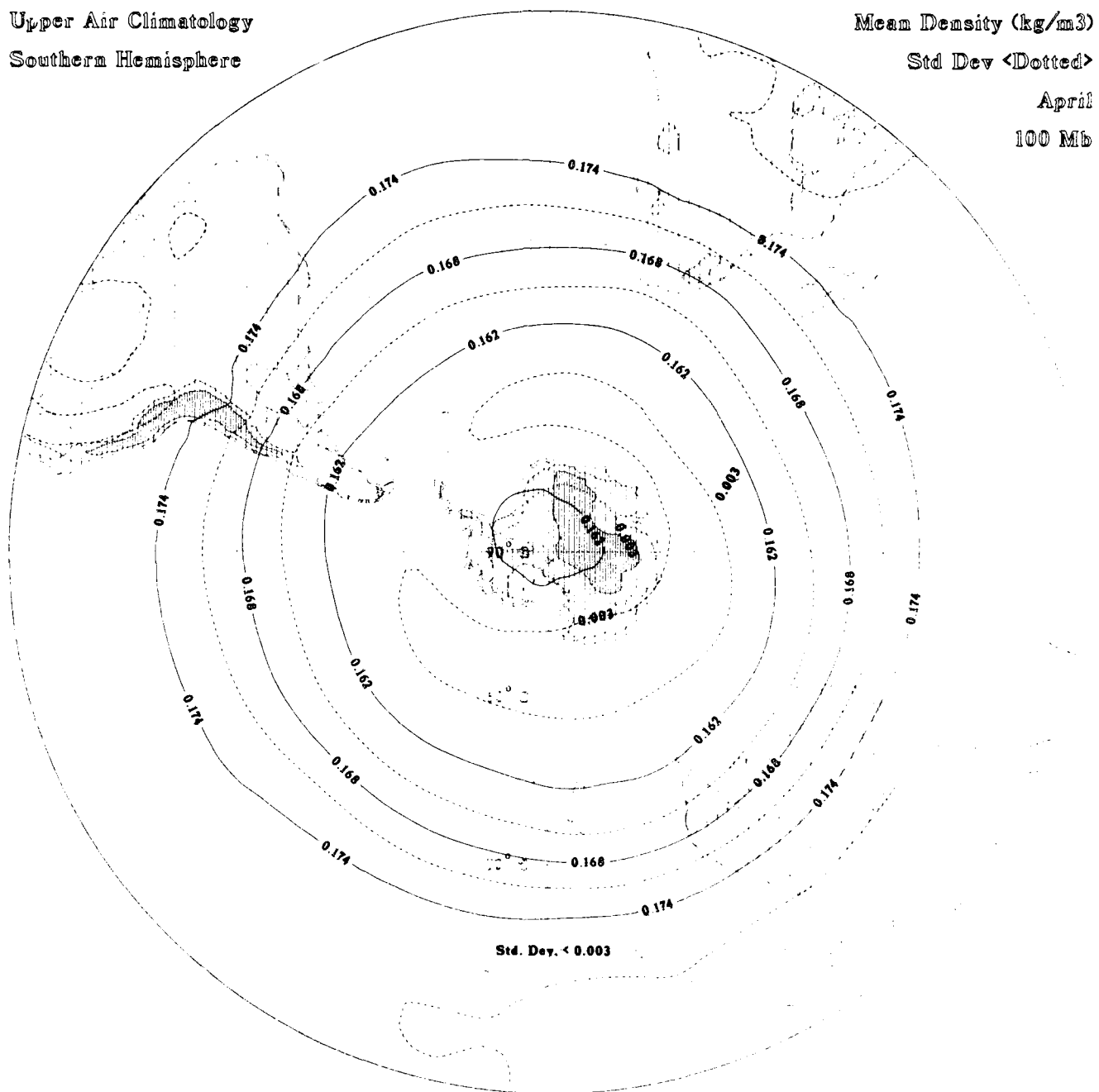
100 MB

Upper Air Climatology

Northern Hemisphere



100 Mb



Mean Density (kg/m³)

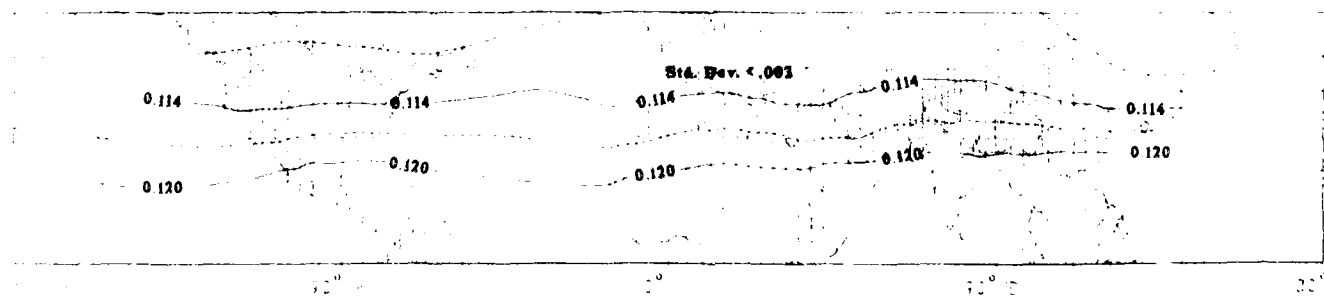
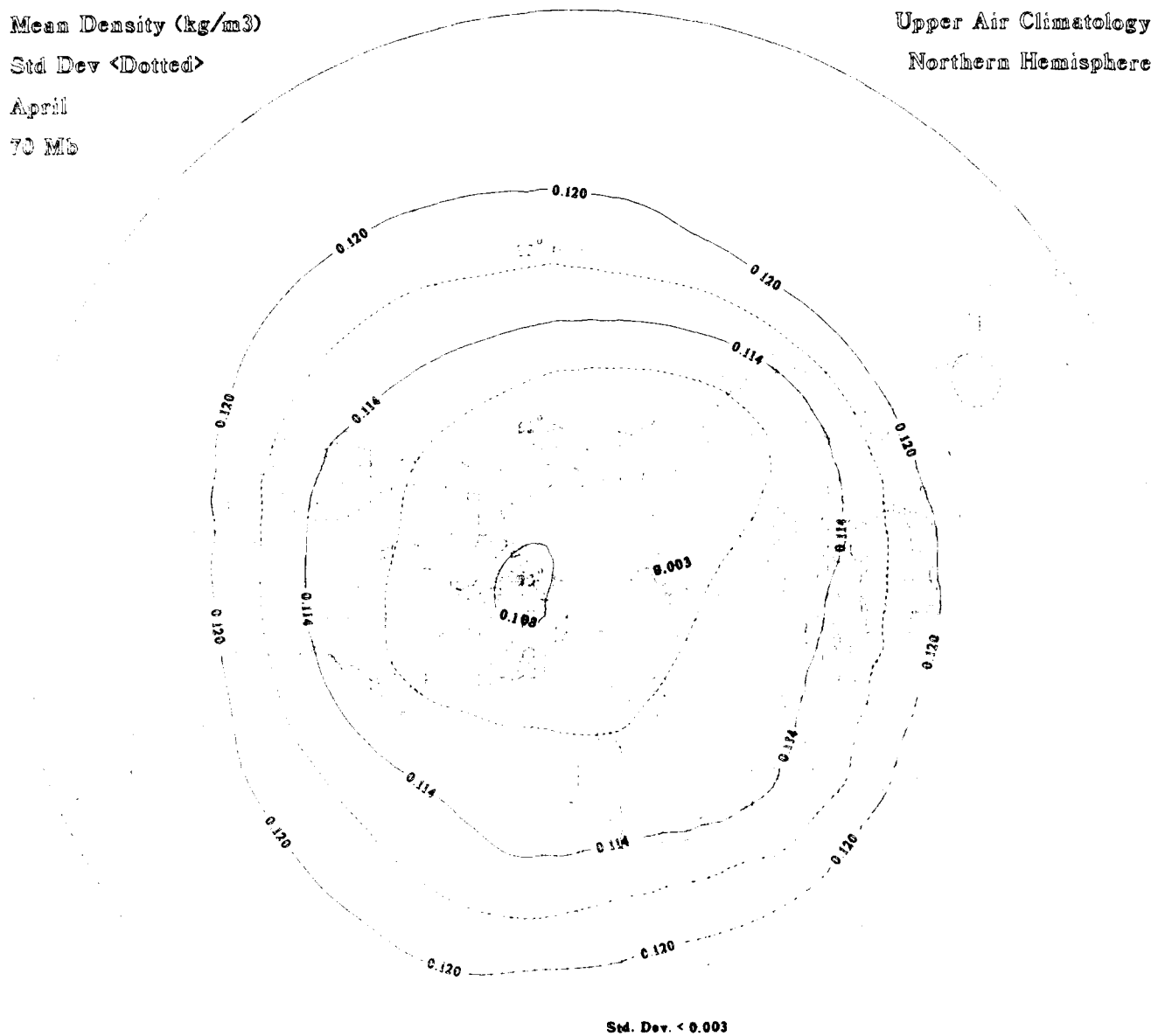
Std Dev <Dotted>

April

70 Mb

Upper Air Climatology

Northern Hemisphere



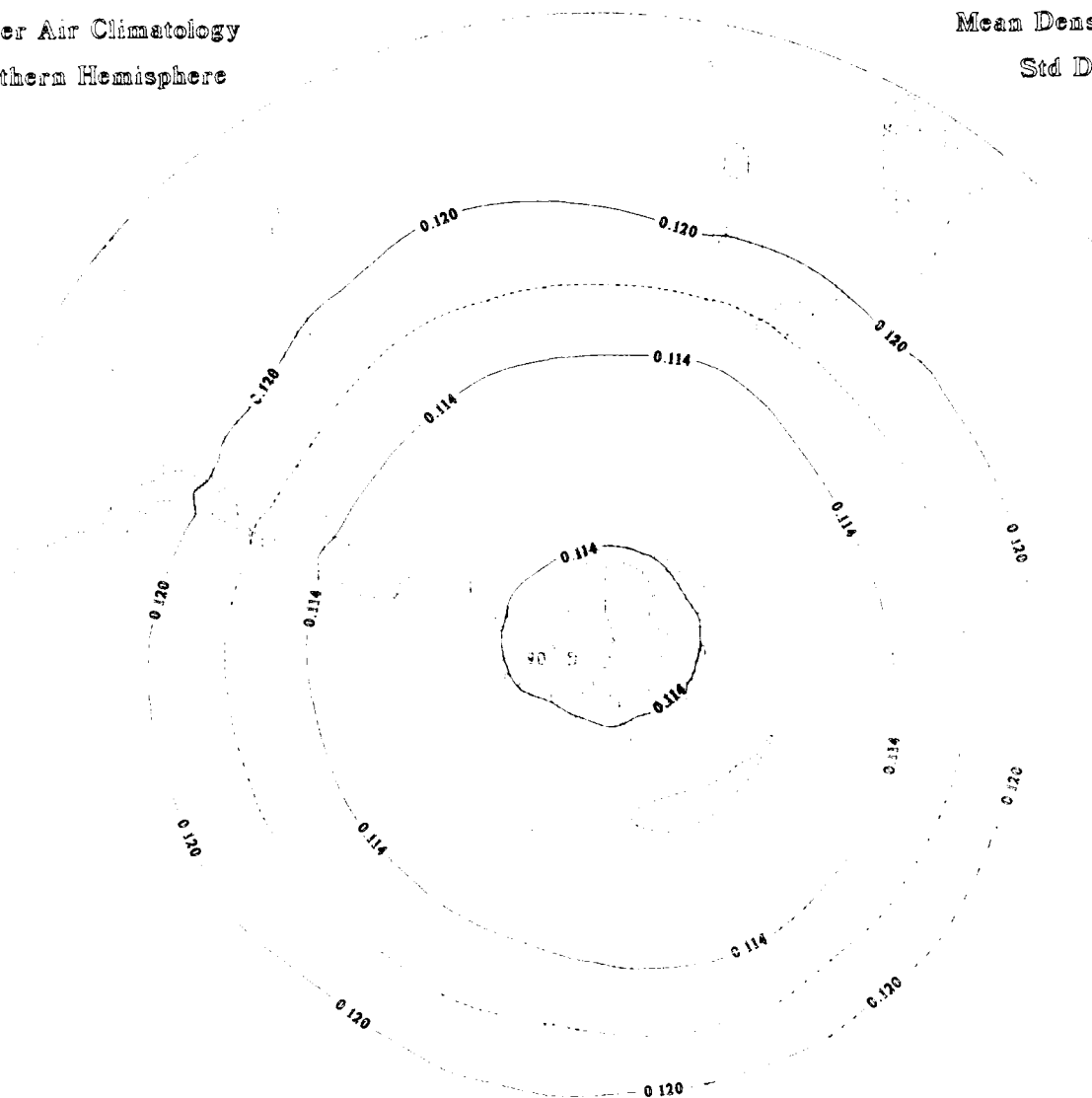
Upper Air Climatology
Southern Hemisphere

Mean Density (kg/m³)

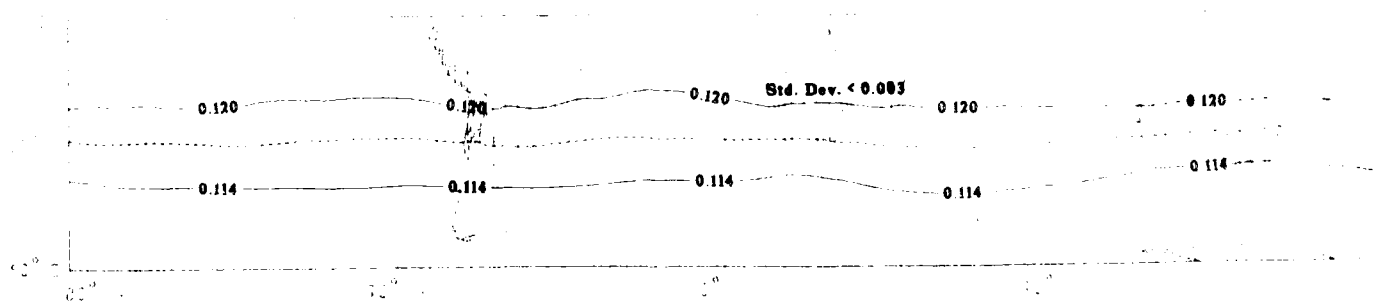
Std Dev <Dotted>

April

70 Mb



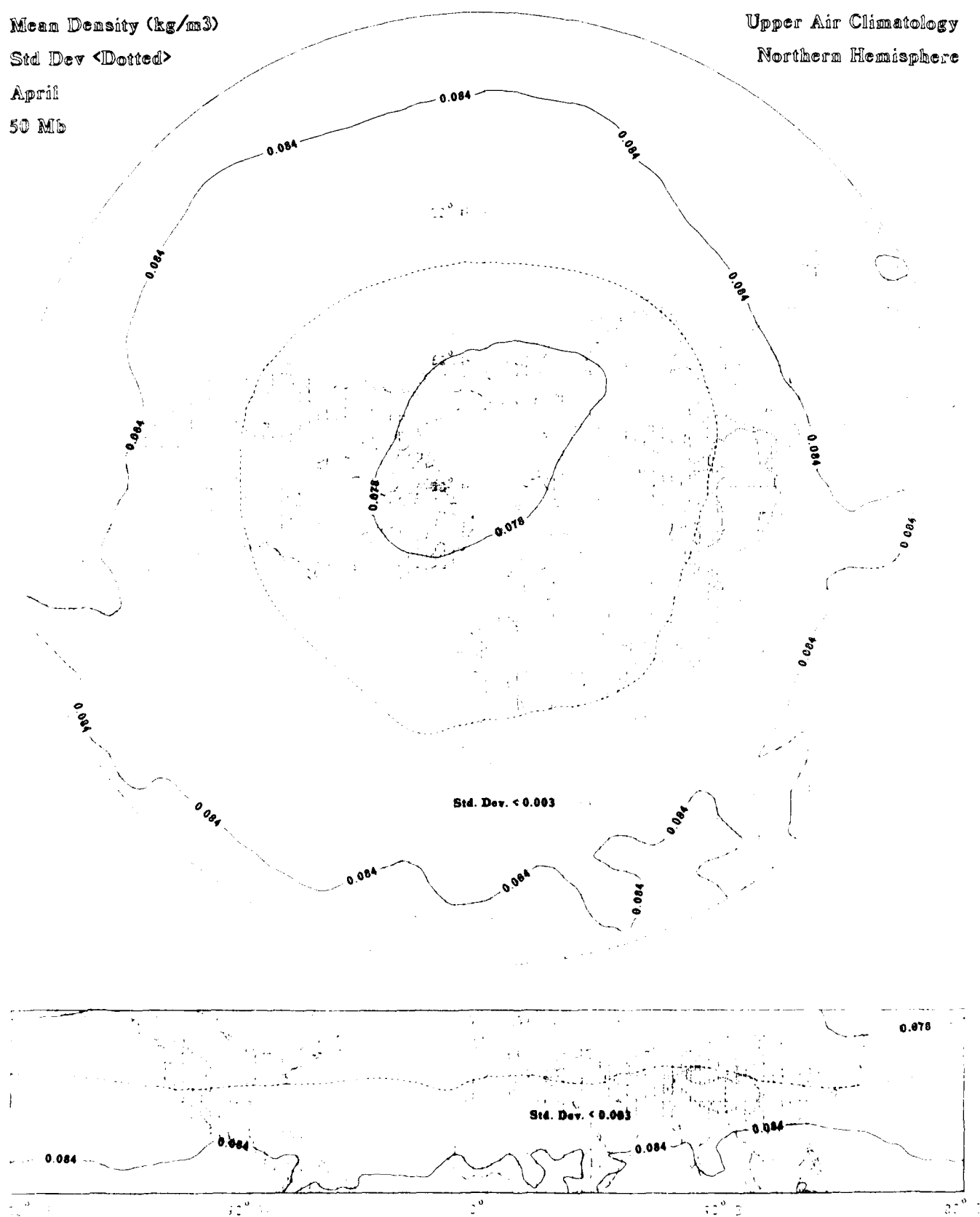
Std. Dev. < 0.003



50 Mb

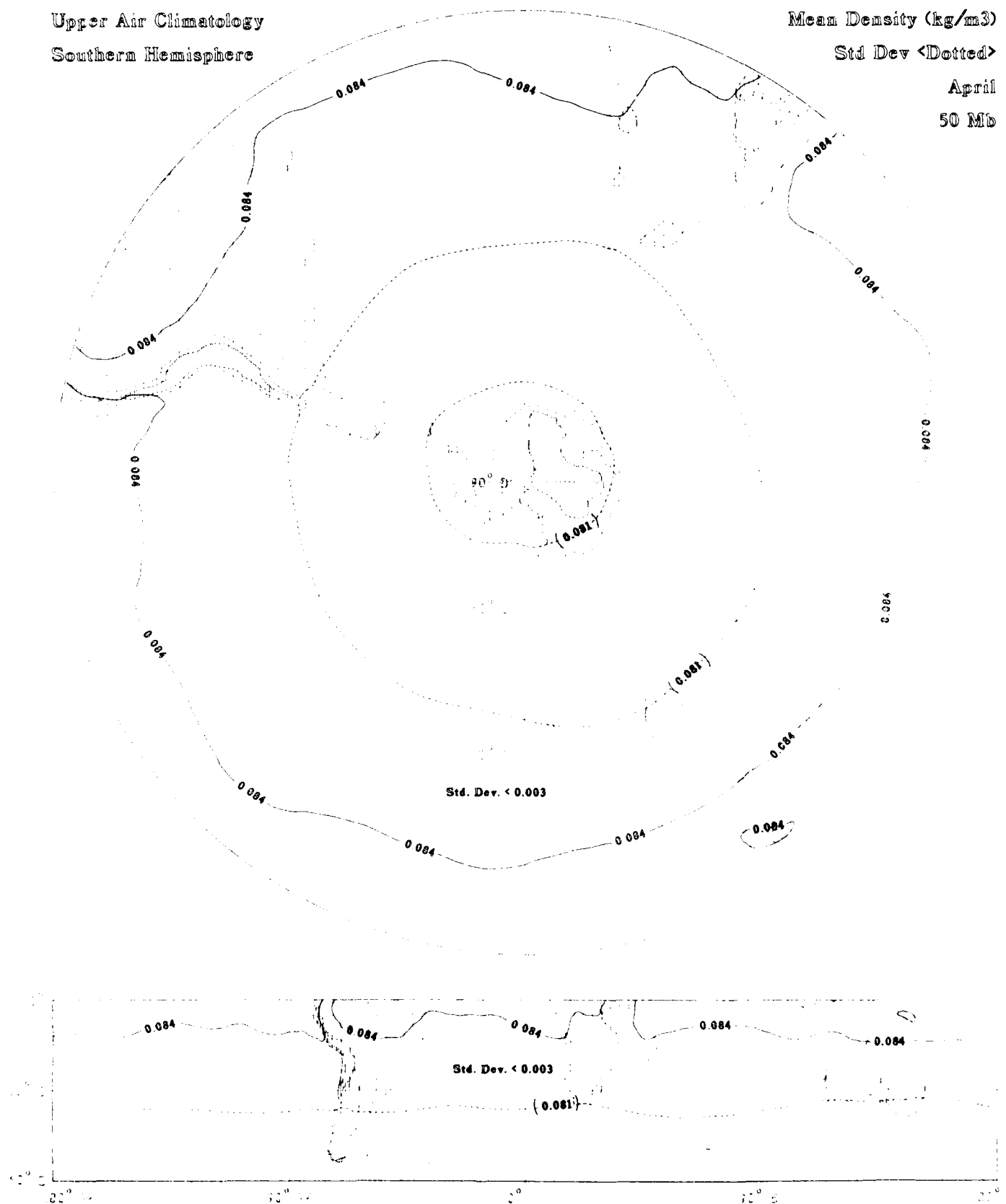
Upper Air Climatology

Northern Hemisphere



Upper Air Climatology
Southern Hemisphere

Mean Density (kg/m³)
Std Dev <Dotted>
April
50 Mb



Mean Density (kg/m³)

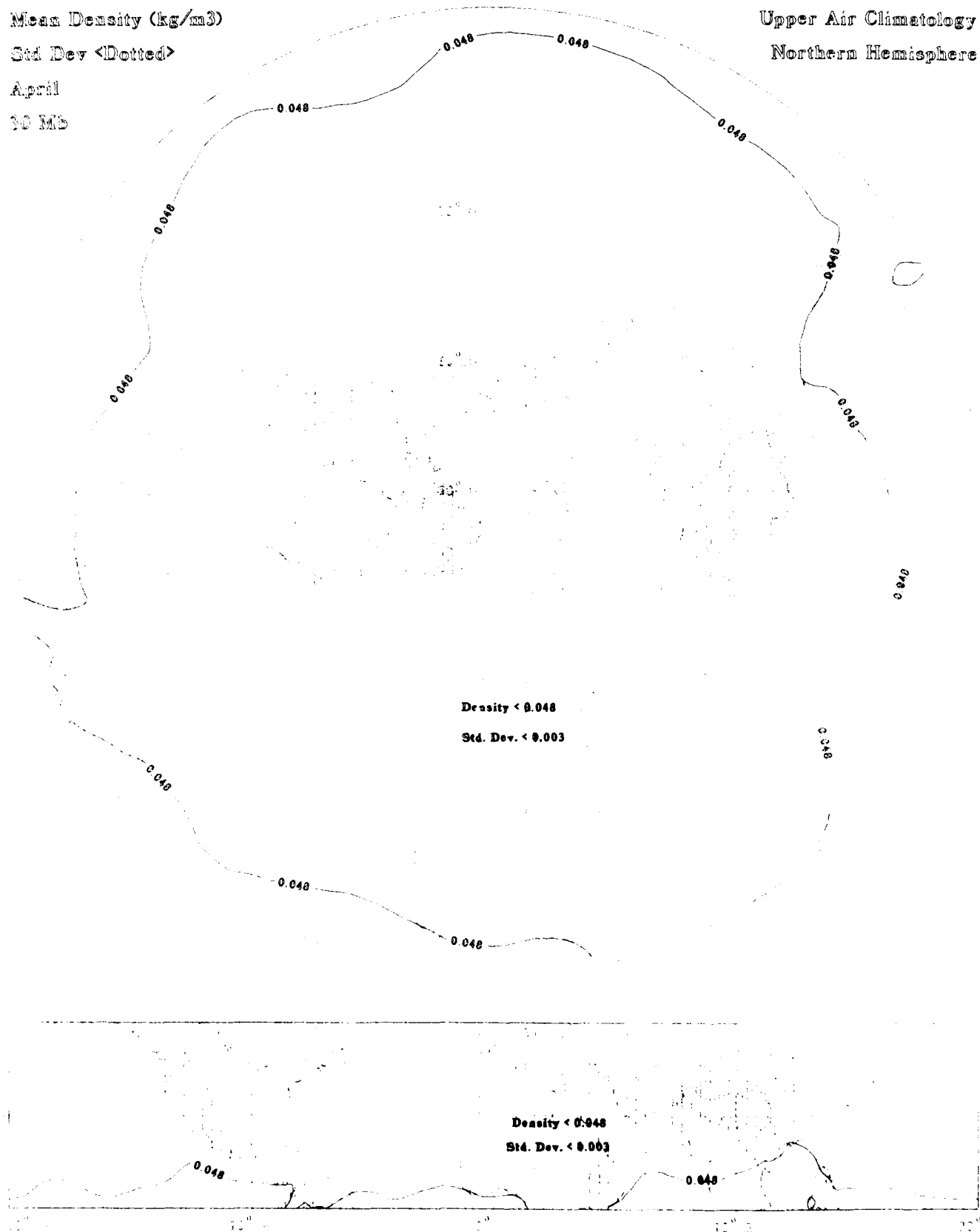
Std Dev <Dotted>

April

30 Mb

Upper Air Climatology

Northern Hemisphere



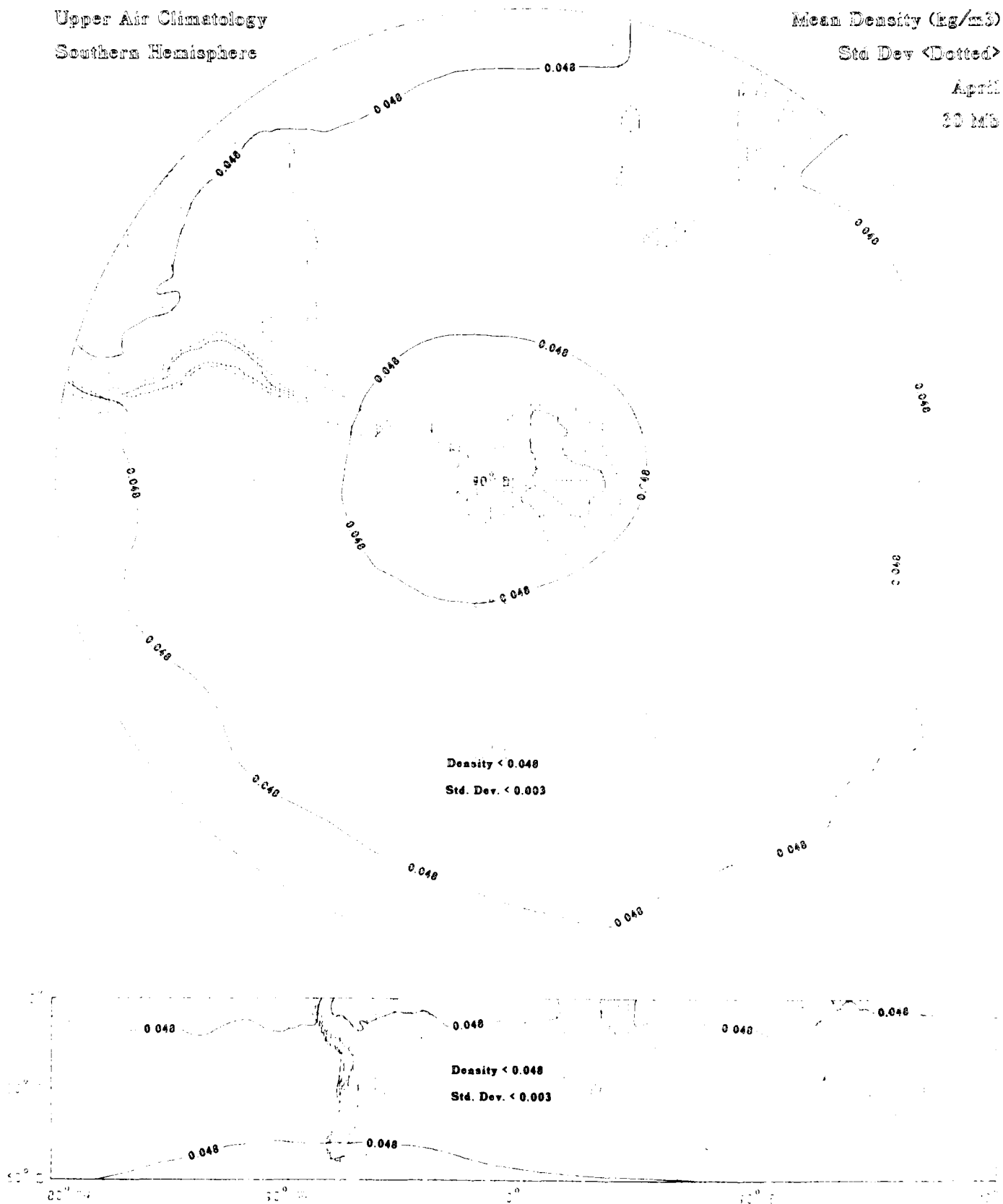
Upper Air Climatology
Southern Hemisphere

Mean Density (kg/m³)

Std Dev <Dotted>

April

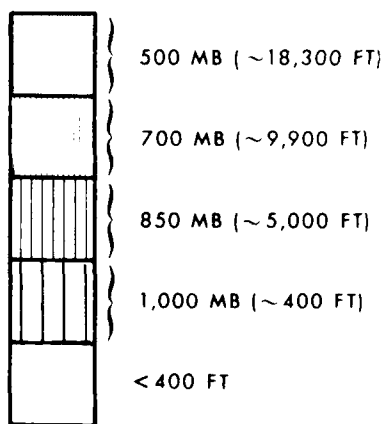
20 MB



**STANDARD DEVIATION OF HEIGHT
STANDARD DEVIATION OF VECTOR MEAN WIND
(13 LEVELS, 1000 TO 30 MB)**

- Contours of standard deviation of height (solid lines) in geopotential dekameters
- Standard deviation of height labeled interval:
 - 3 dekameters (30 meters) - 1000 MB to 400 MB
 - 6 dekameters (60 meters) - 300 MB to 200 MB
 - 4 dekameters (40 meters) - 150 MB to 30 MB
- Contours of standard deviation of vector mean wind (dashed lines) in knots
- Standard deviation of vector mean wind labeled interval: 5 knots
- Contours blanked for geographic areas with elevations exceeding specified geopotential heights

ELEVATION SCALE



Height (dkm) Std Dev <Solid>

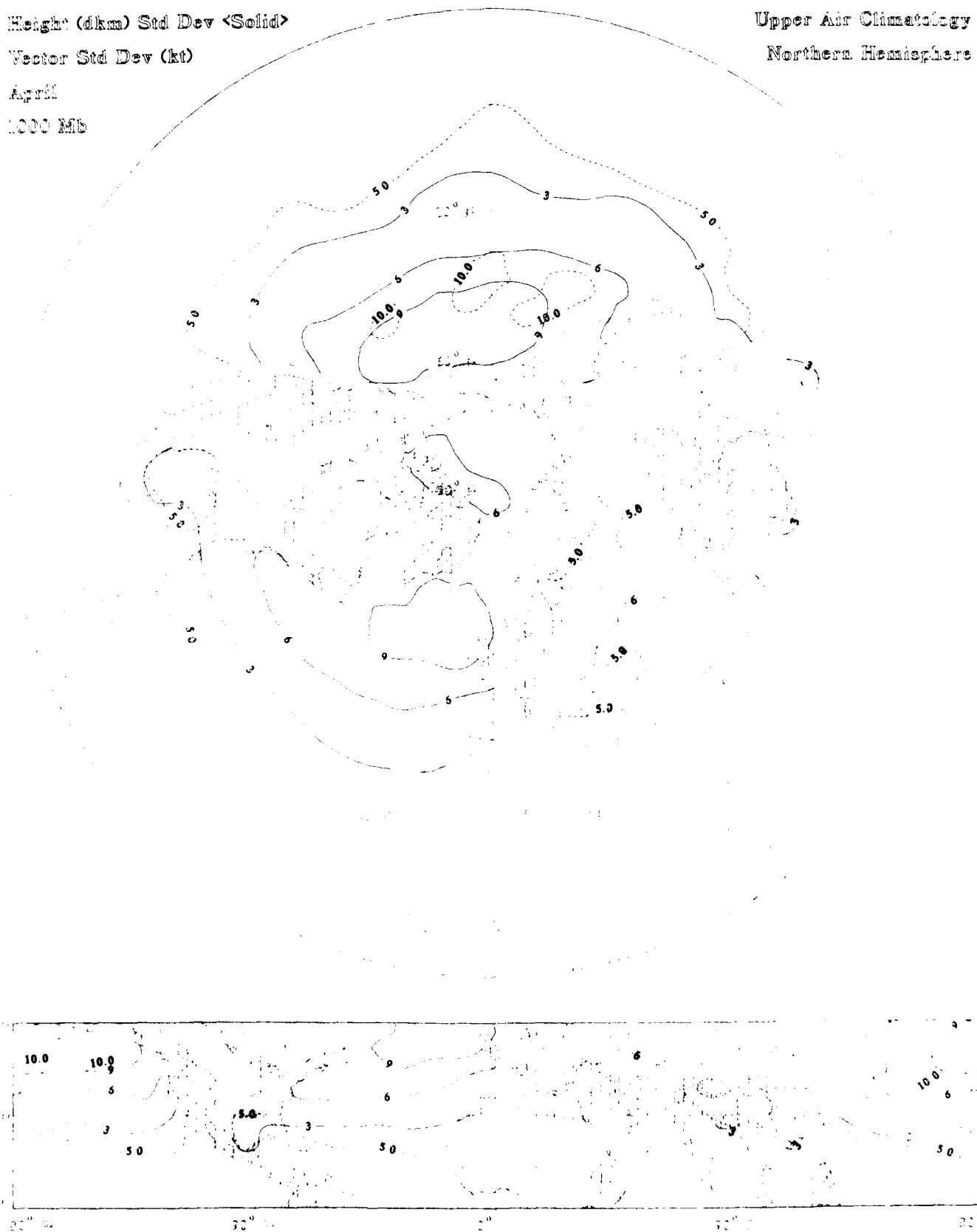
Vector Std Dev (kt)

April

1000 Mb

Upper Air Climatology

Northern Hemisphere



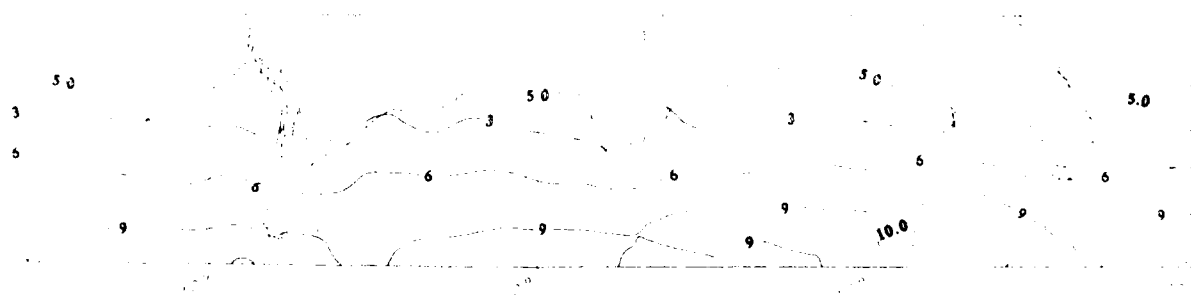
Upper Air Climatology
Southern Hemisphere

Height (dkm) Std Dev <Cont>

Vector Std Dev (kt)

April

1000 MB



Height (km) Std Dev (Solid)

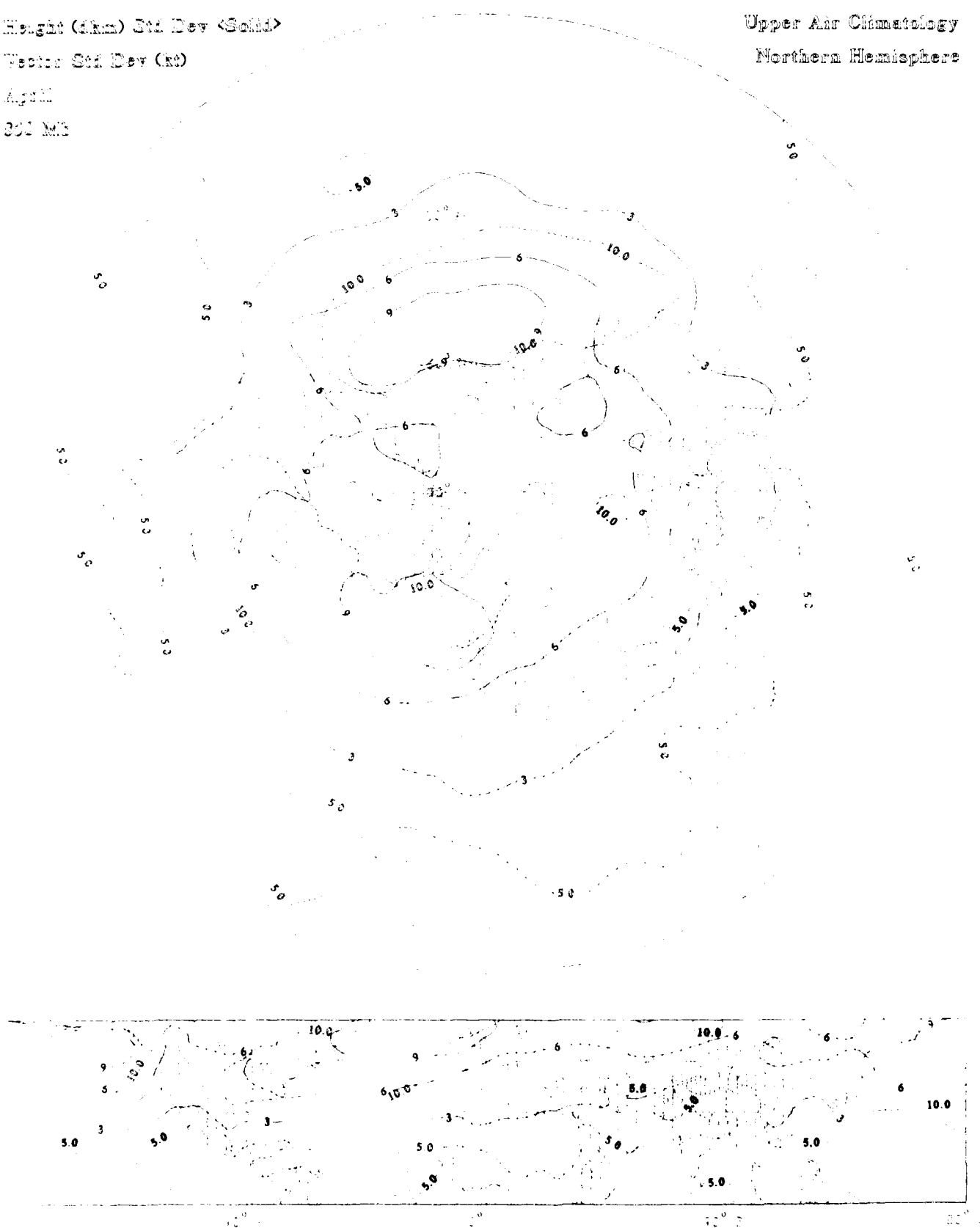
Tested Std Dev (dashed)

April

301 MB

Upper Air Climatology

Northern Hemisphere



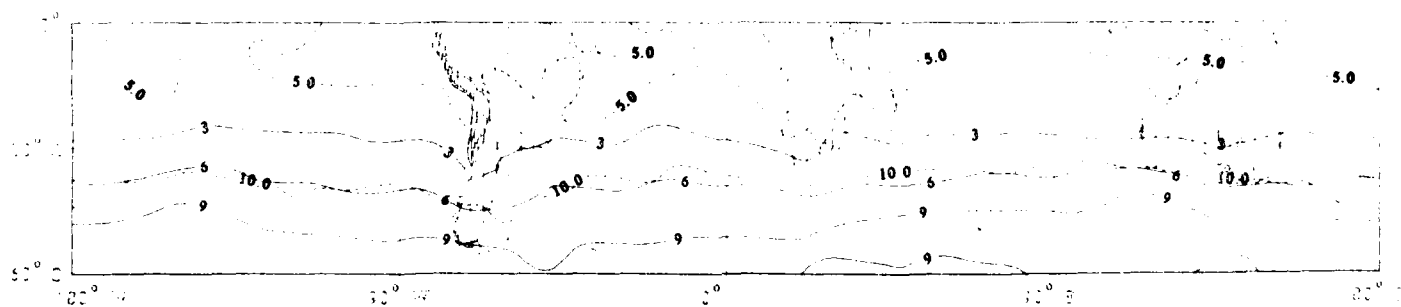
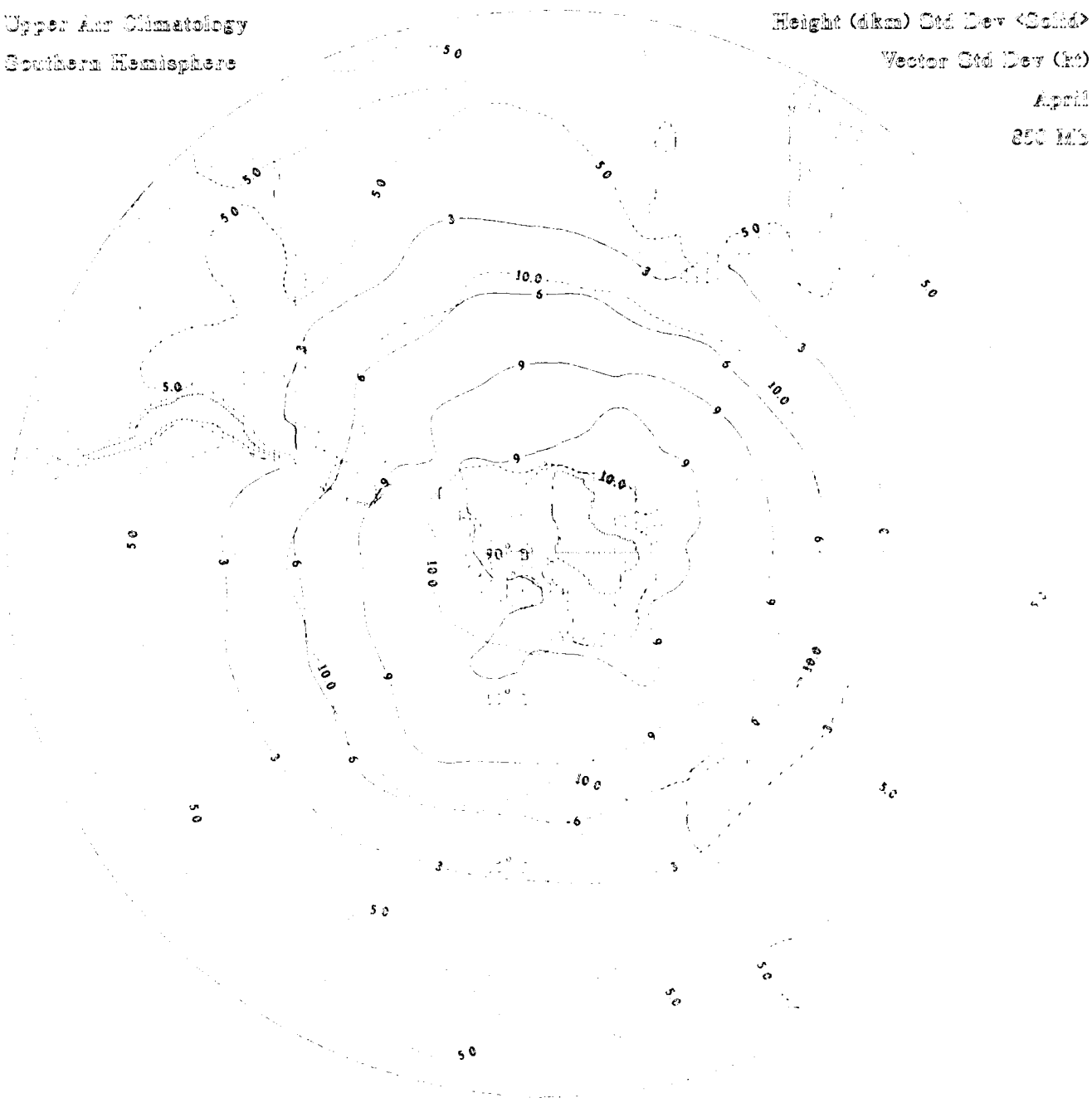
Upper Air Climatology
Southern Hemisphere

Height (dkm) Std Dev <Solid>

Vector Std Dev (k)

April

850 mb



Height (dkm) Std Dev <Solid>

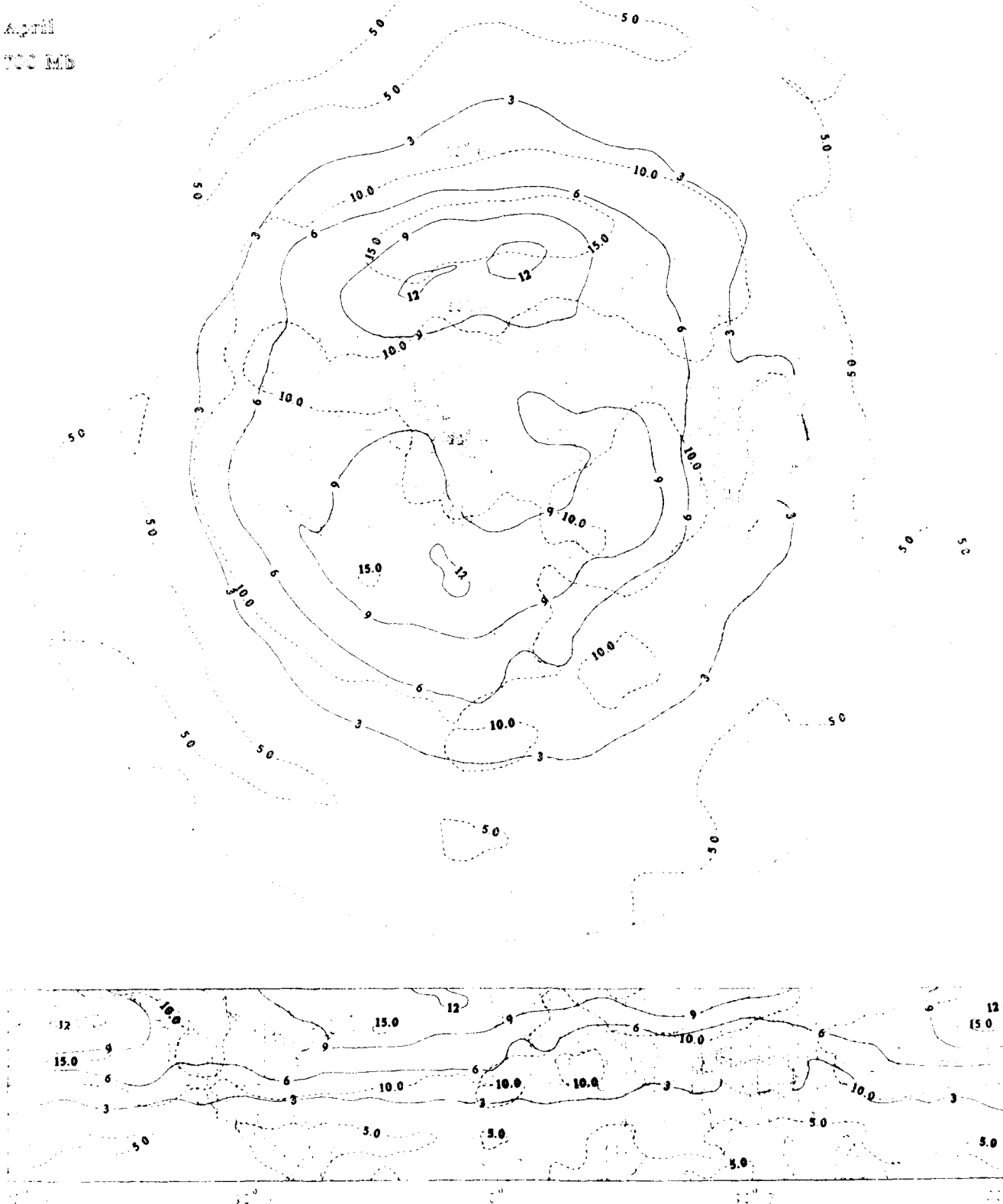
Vector Std Dev (kt)

April

700 Mb

Upper Air Climatology

Northern Hemisphere



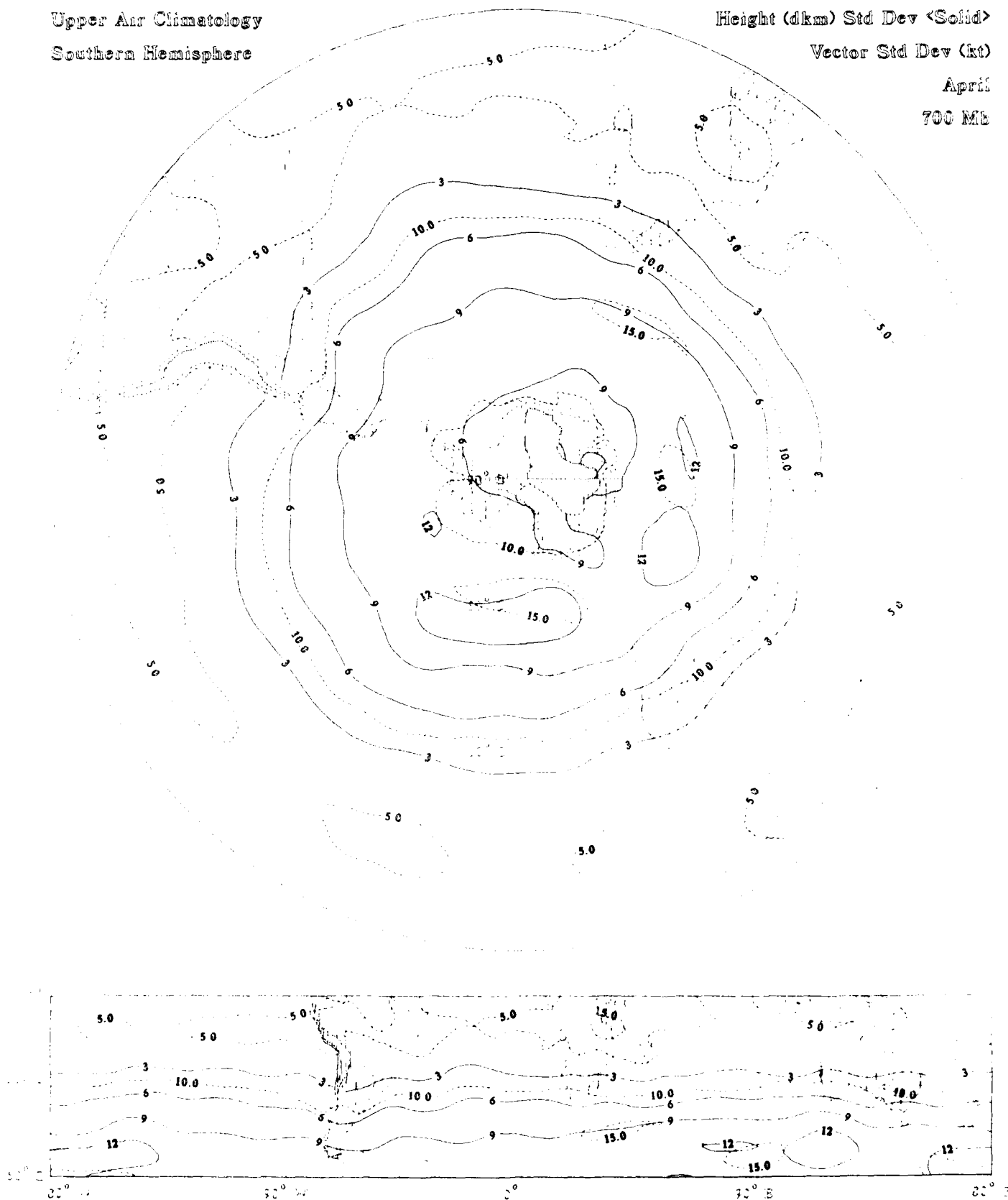
Upper Air Climatology
Southern Hemisphere

Height (dkm) Std Dev <Solid>

Vector Std Dev (kt)

April

700 MB



Height (dkm) Std Dev <Solid>

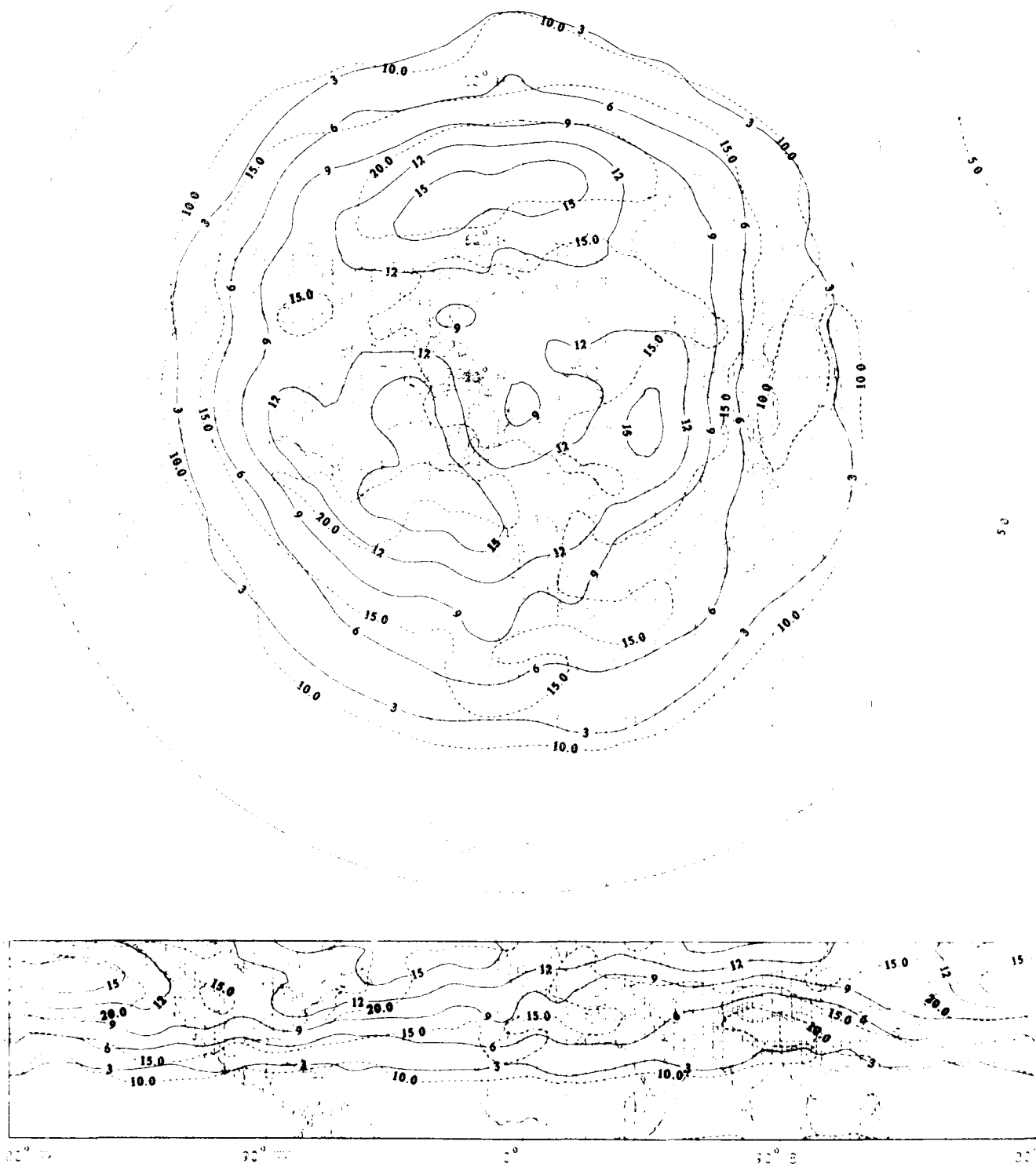
Vector Std Dev (kt)

April

500 Mb

Upper Air Climatology

Northern Hemisphere



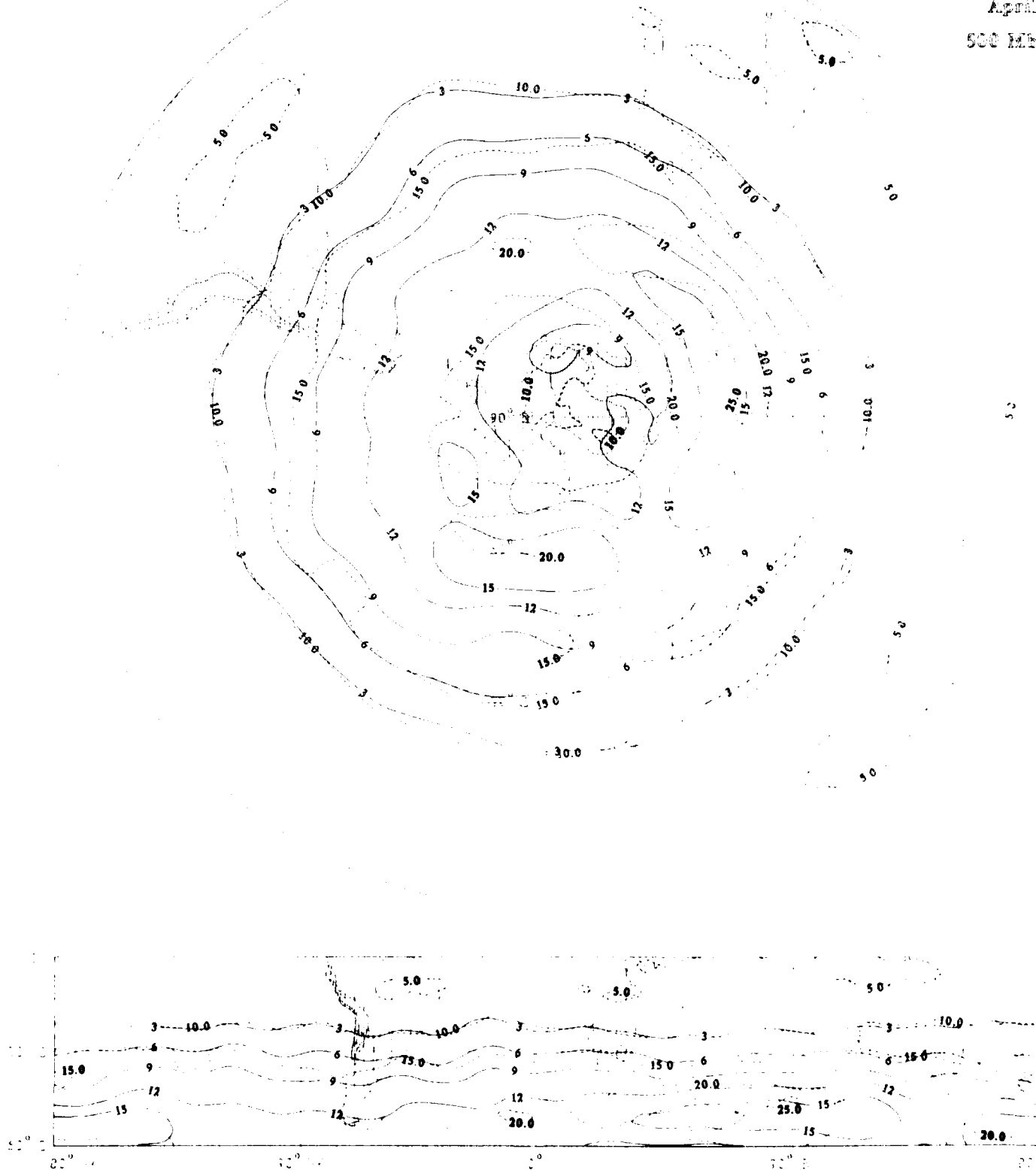
Upper Air Climatology
Southern Hemisphere

Height (dkm) Std Dev <Solid>

Vector Std Dev (kt)

April

500 Mb



Height (dkm) Std. Dev <Solid>

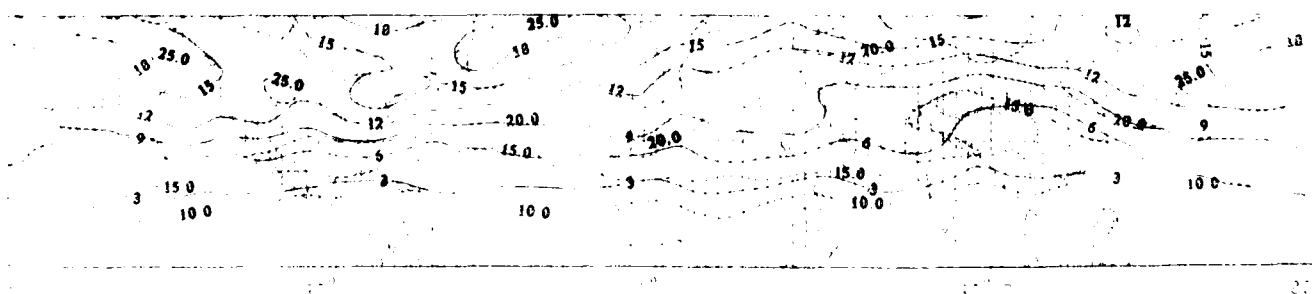
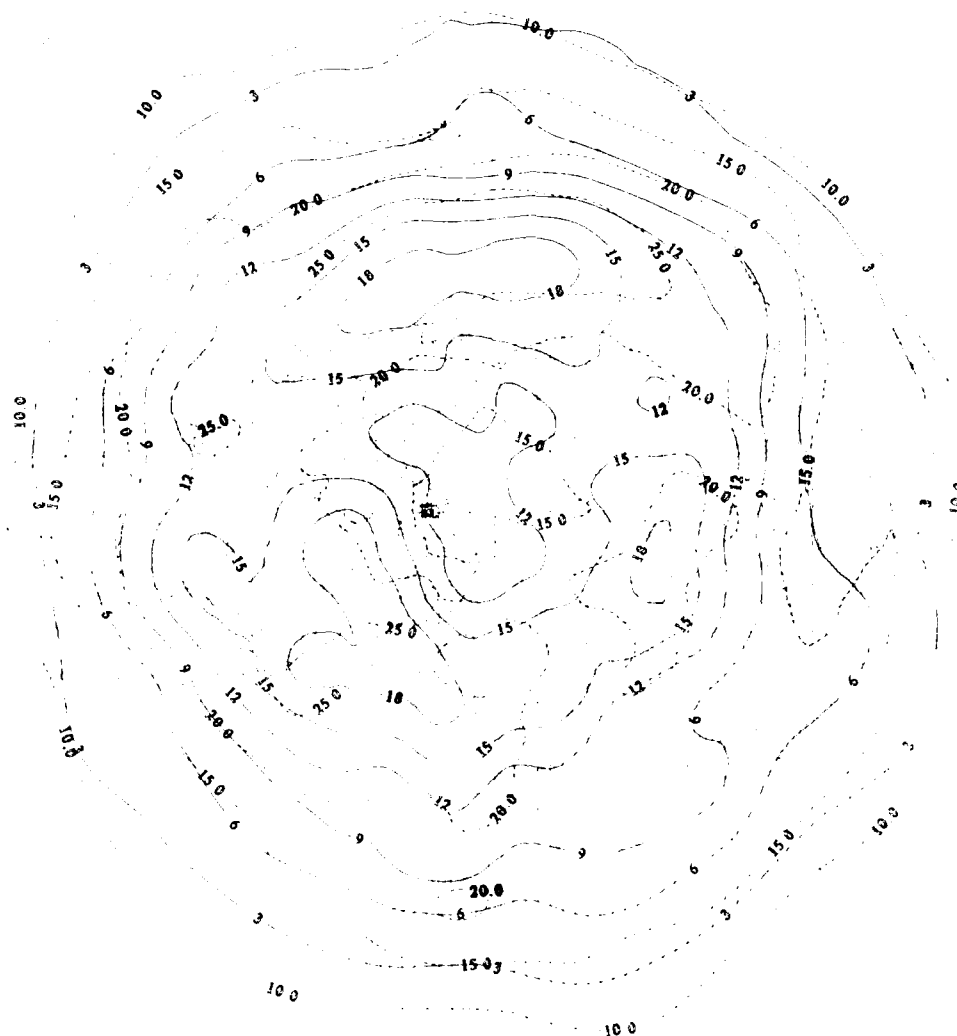
Vector Std Dev (kt)

April

400 MB

Upper Air Climatology

Northern Hemisphere



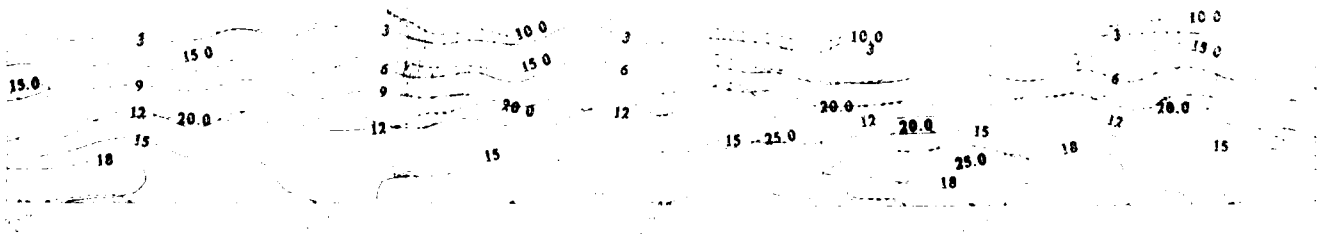
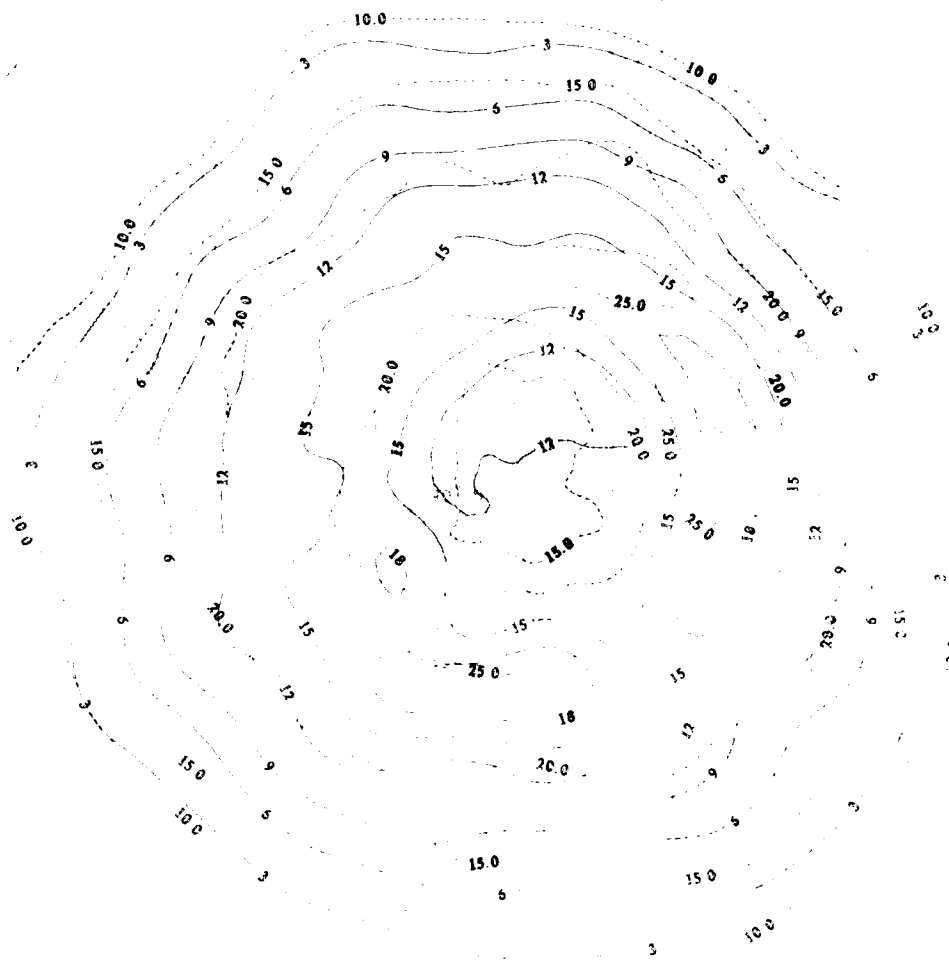
Upper Air Climatology
Southern Hemisphere

Height (dkm) Std Dev (Solid)

Vector Std Dev (dashed)

April

400 MB



Height (km) Std Dev (Solid)

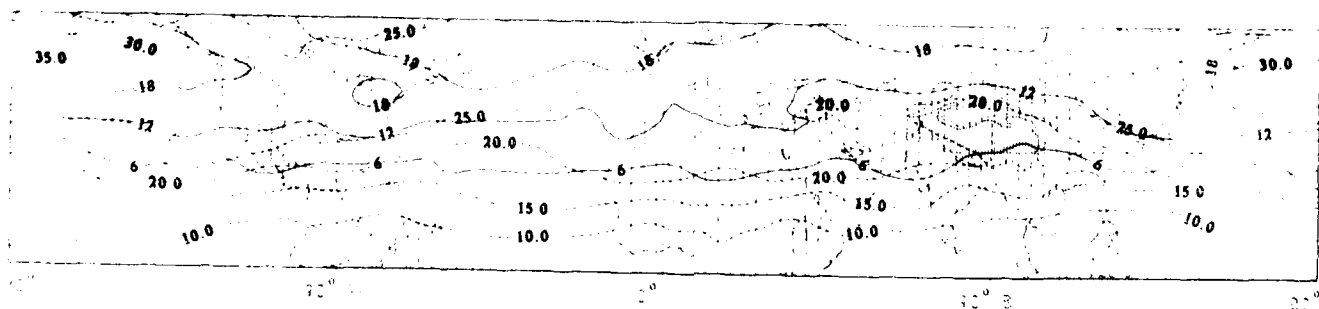
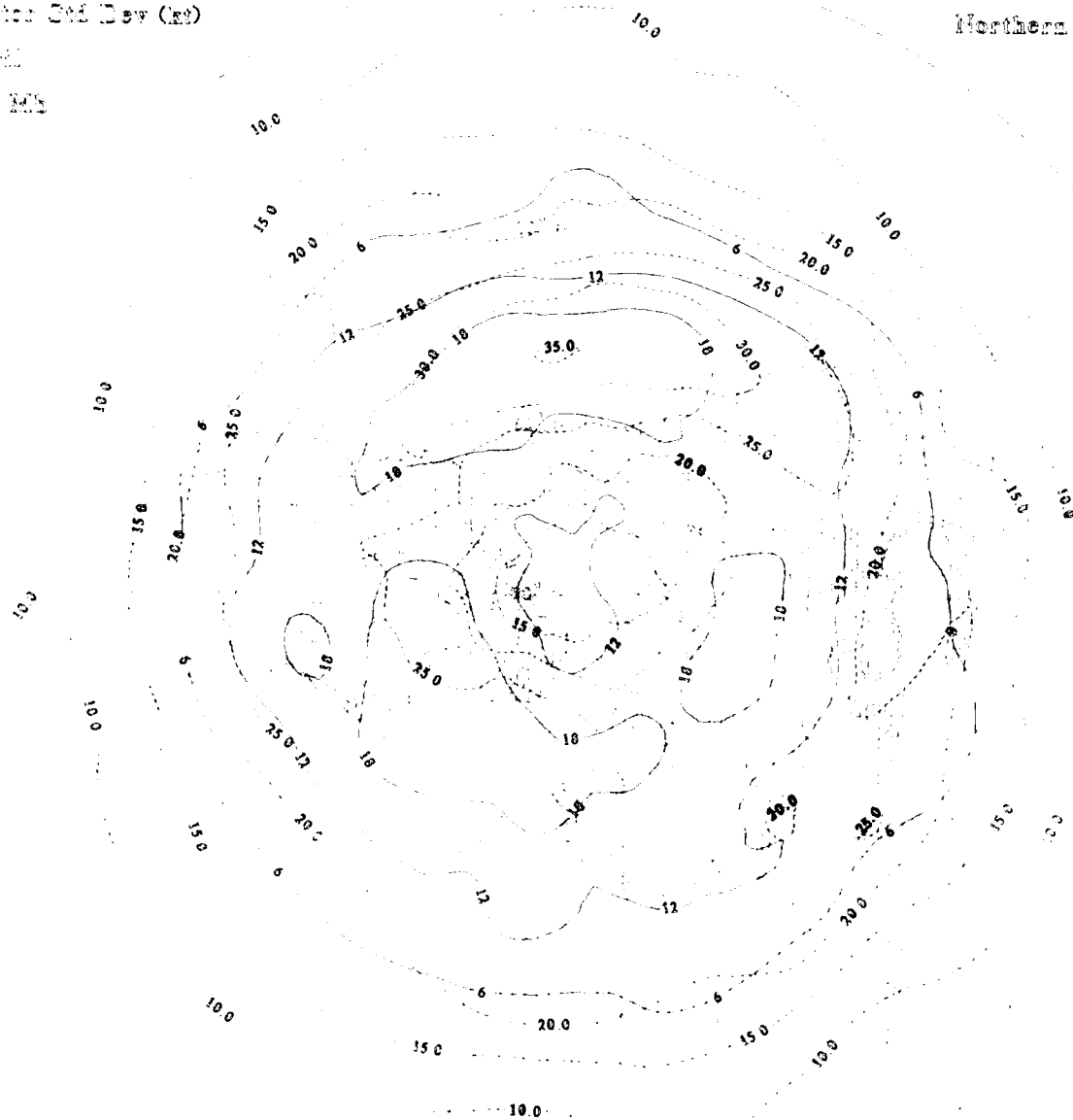
Wester Std Dev (Dashed)

April

111 MS

Upper Air Climatology

Northern Hemisphere



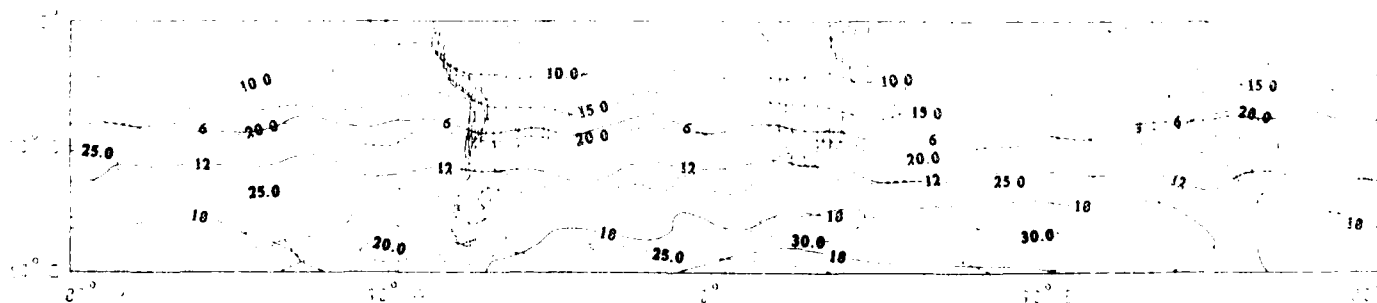
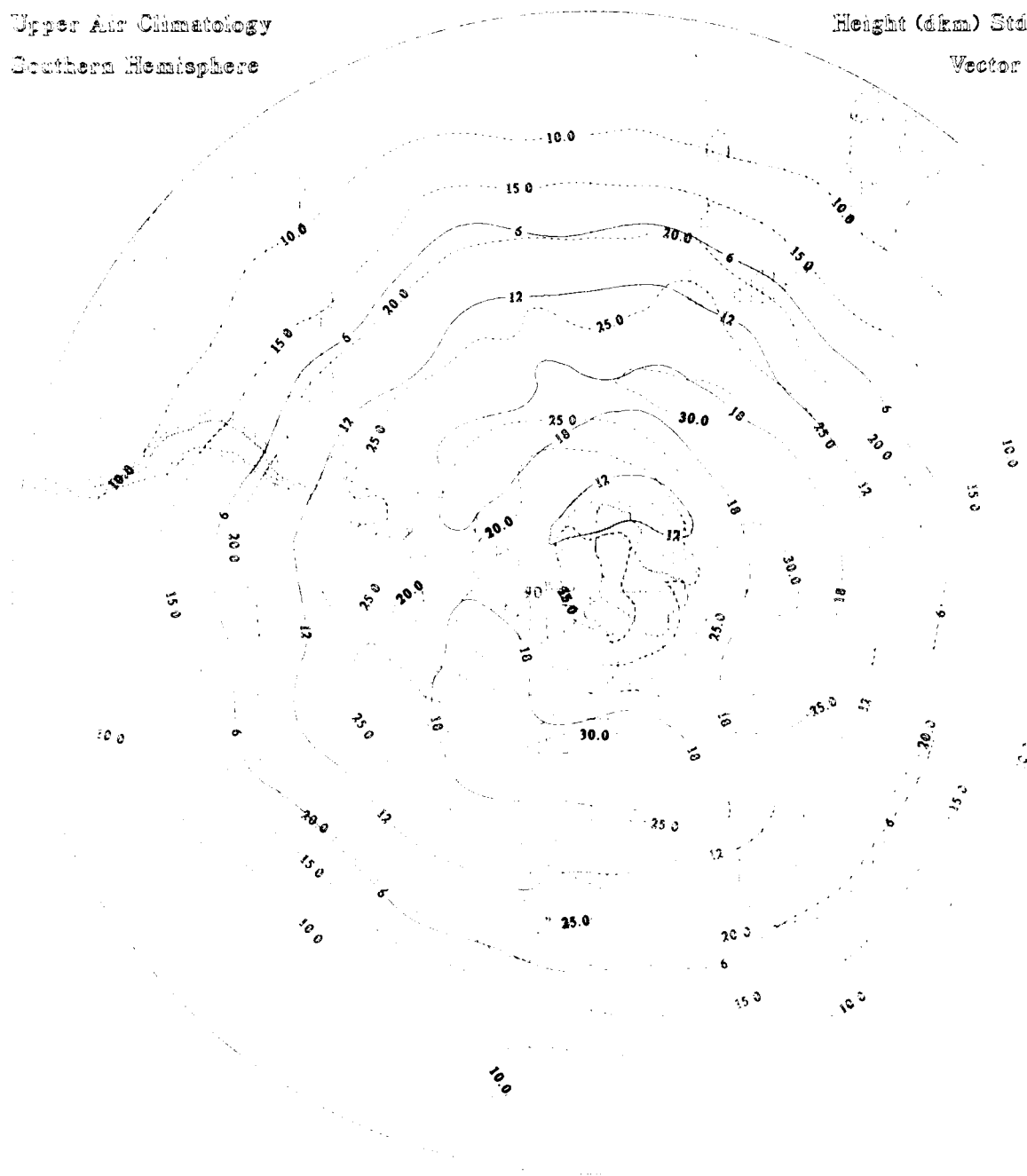
Upper Air Climatology
Southern Hemisphere

Height (dkm) Std Dev <Solid>

Vector Std Dev (kt)

April

300 MB



Height (dkm) Std. Dev <Solid>

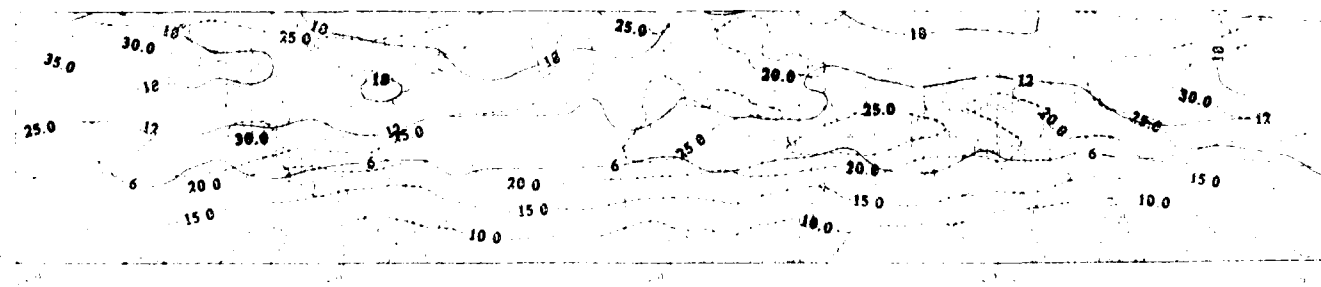
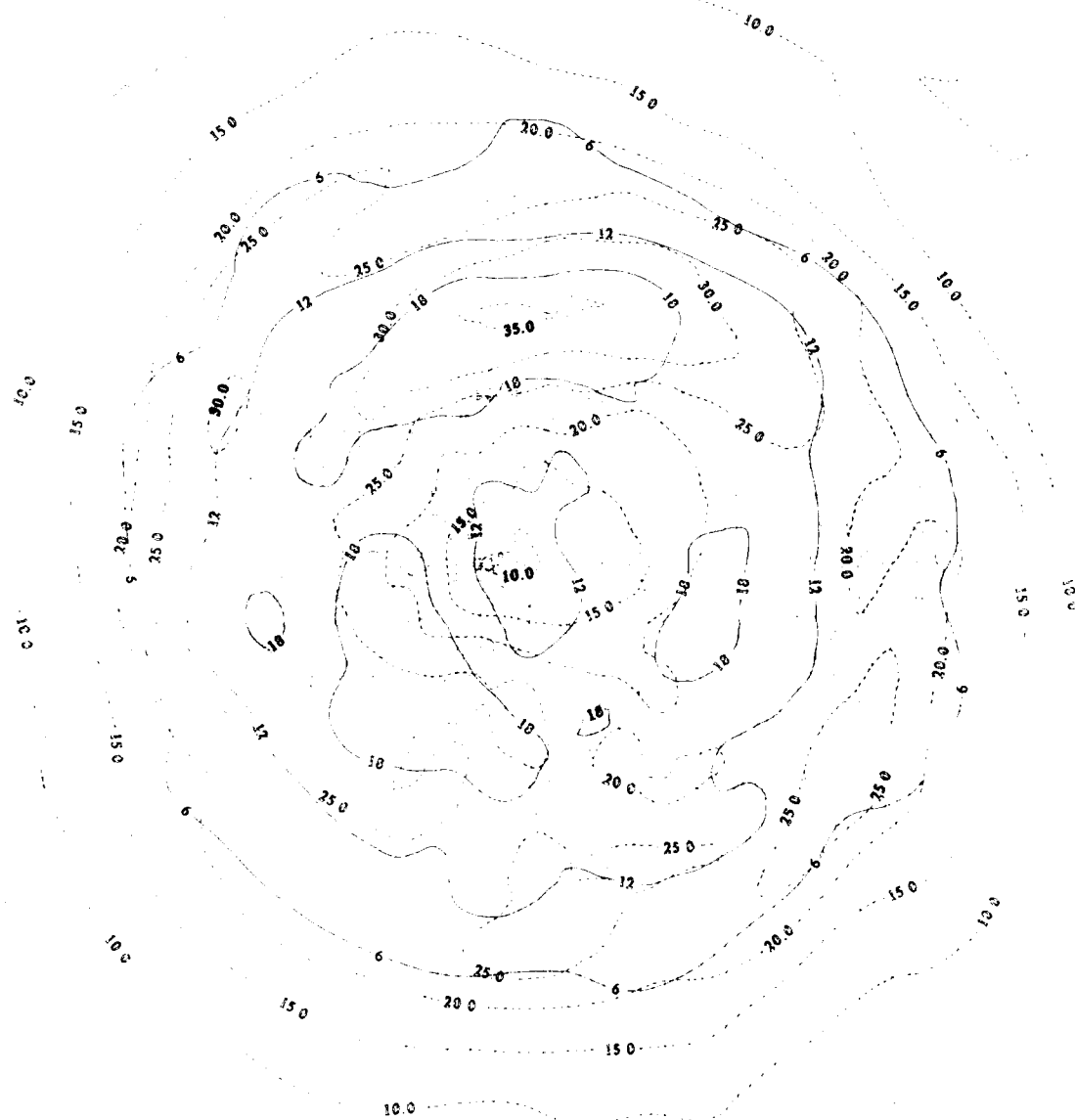
Vector Std. Dev (kt)

April

150 MS

Upper Air Climatology

Northern Hemisphere



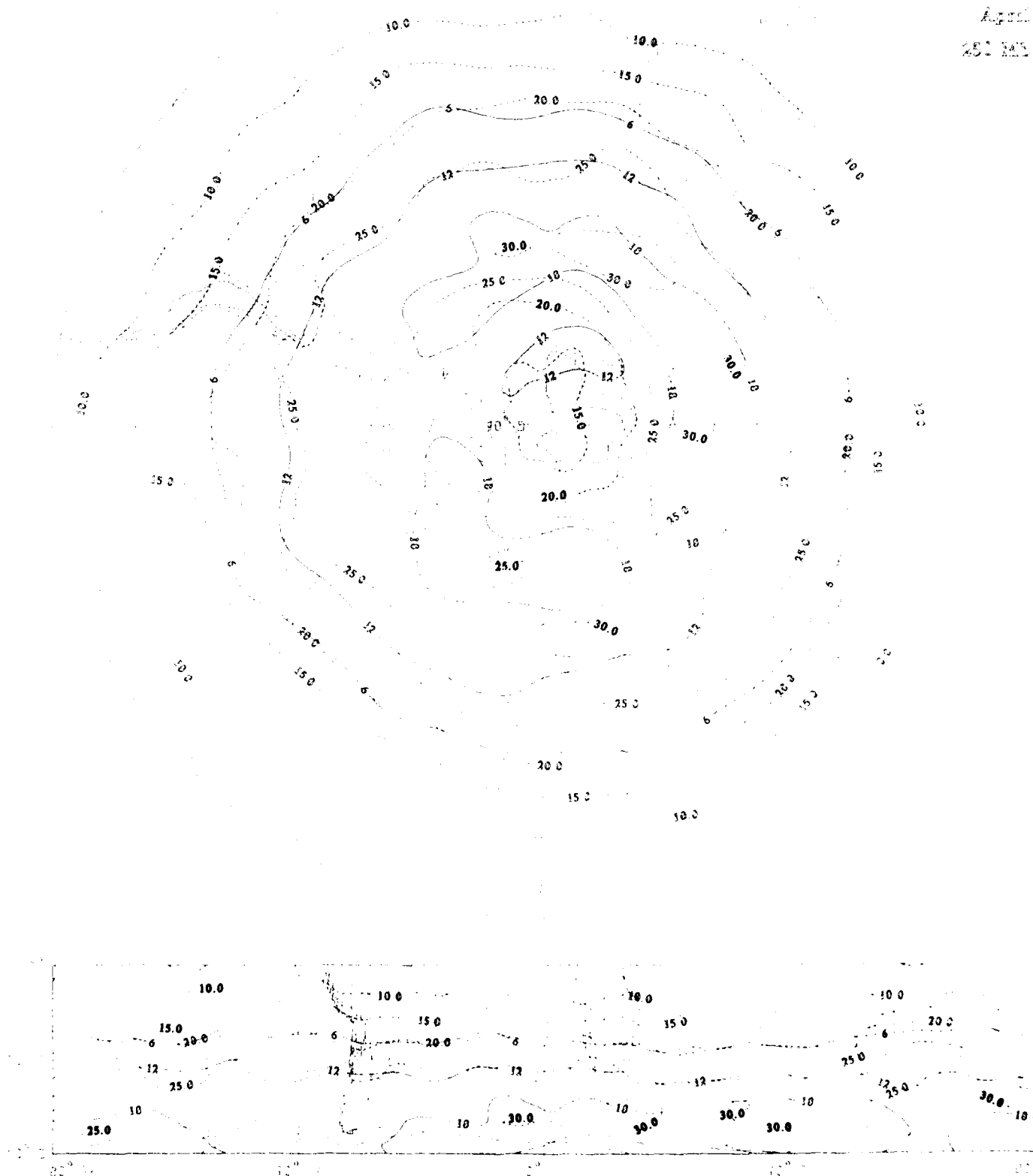
Upper Air Climatology
Southern Hemisphere

Height (dkm) Std Dev (Solid)

Vector Std Dev (in)

April

251 145



Height (kms) Std Dev <Solid>

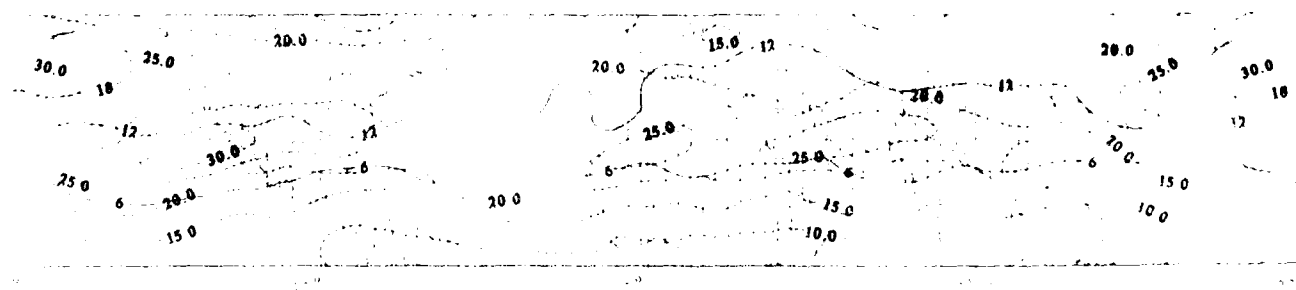
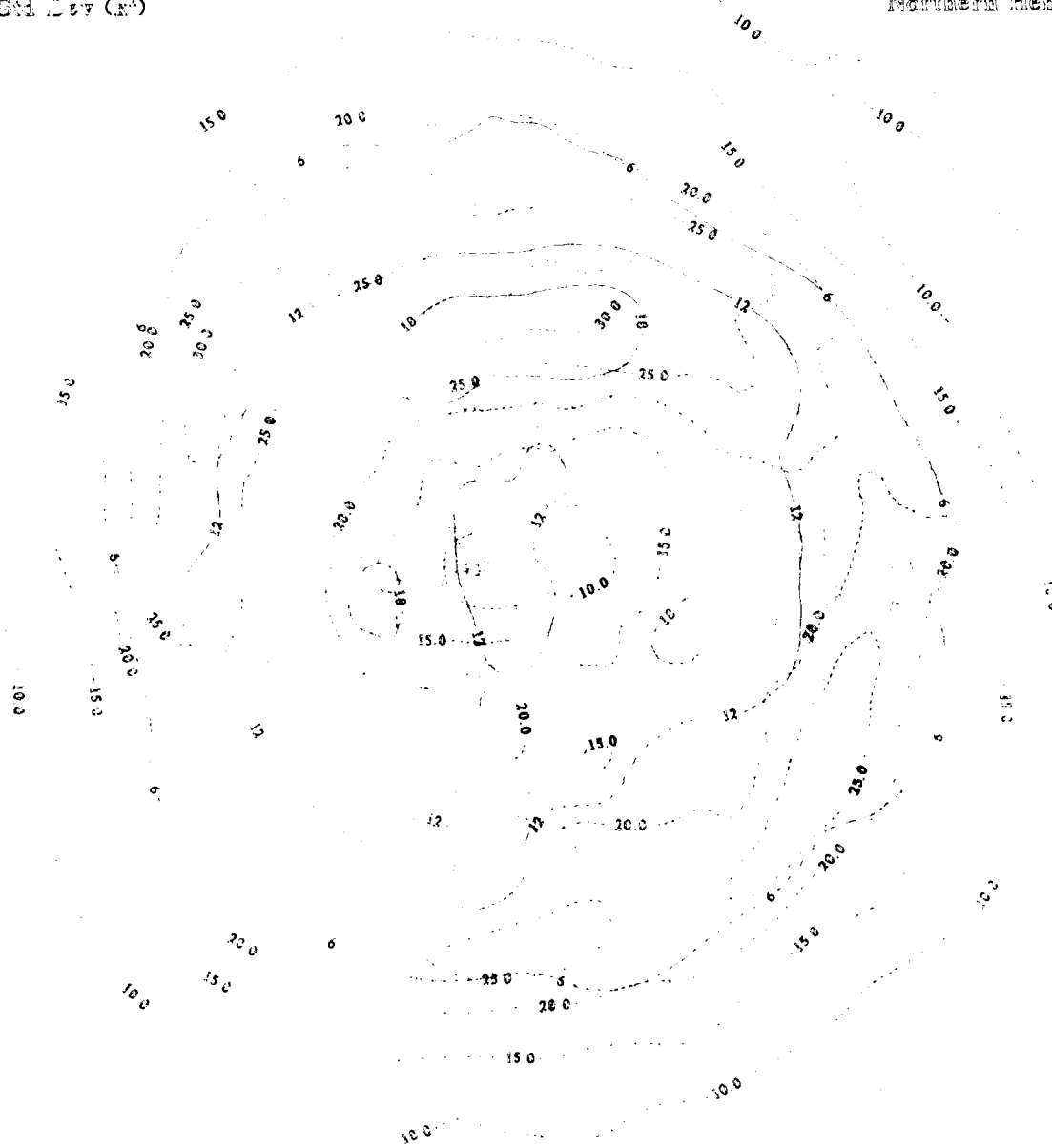
Vector Std Dev (kt)

April

400 HPa

Upper Air Climatology

Northern Hemisphere



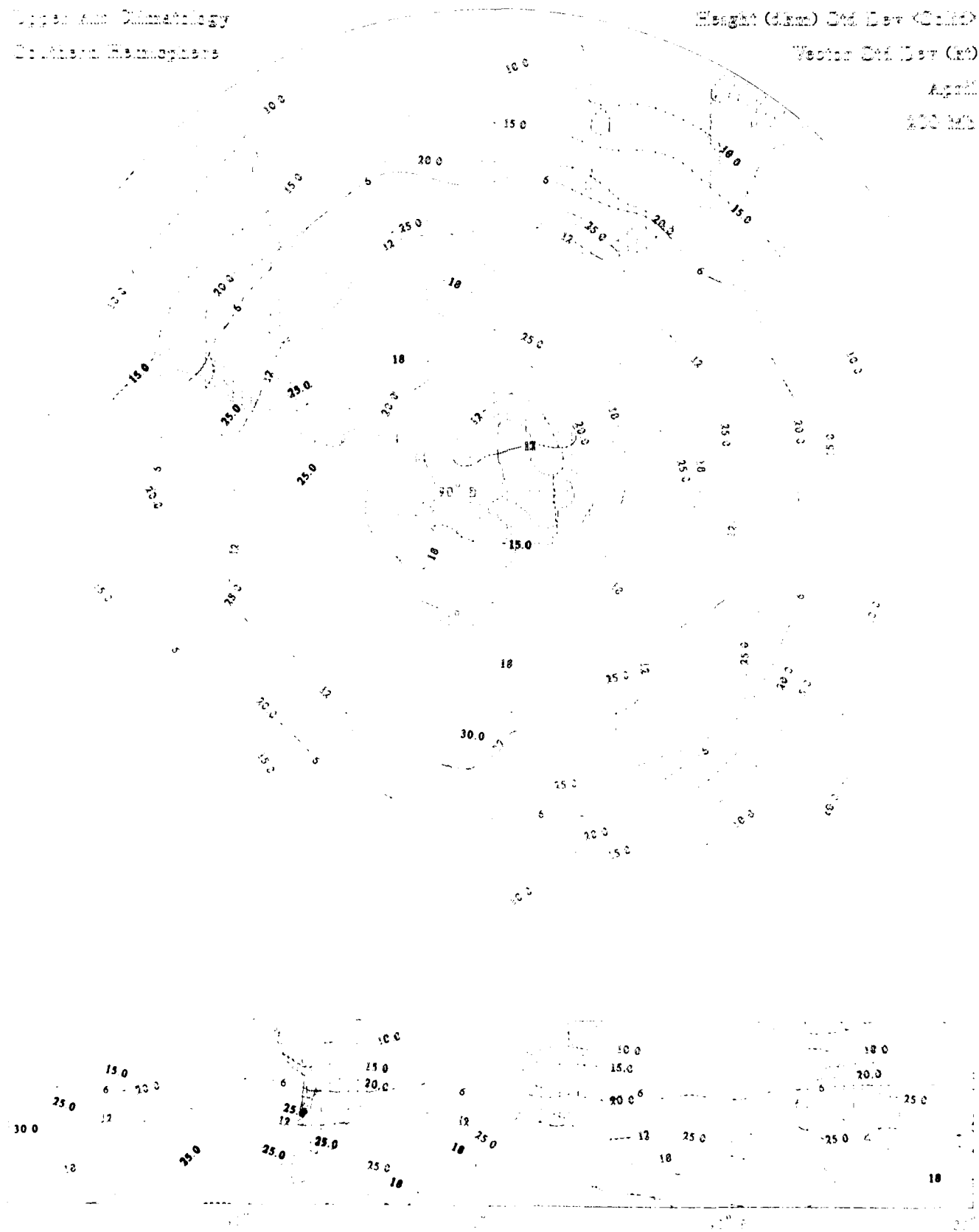
Upper Air Climatology
 Northern Hemisphere

Height (km) Std Dev (km)

Vector Std Dev (km)

April

200 mb



Height (km) Std Dev <Solid>

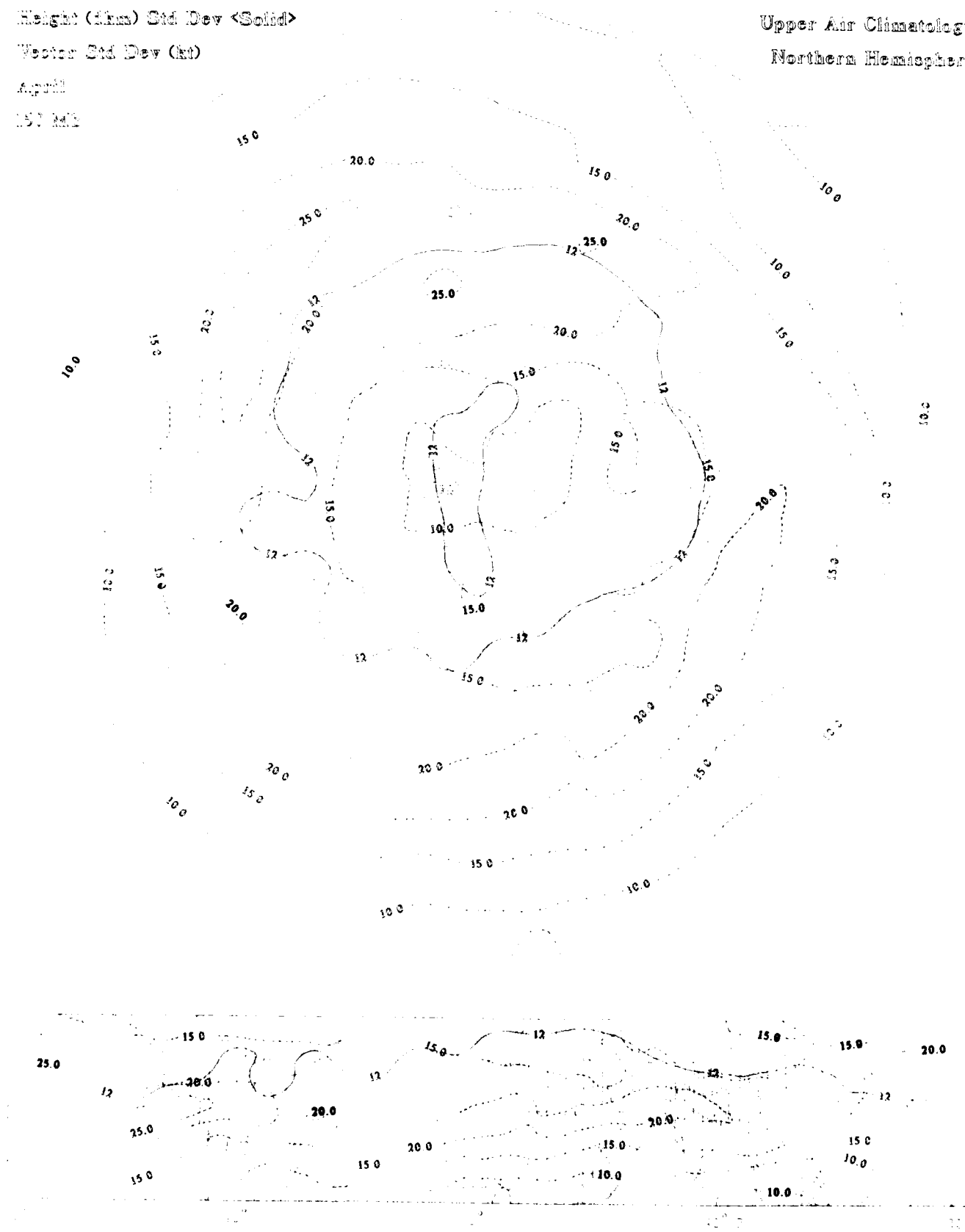
Vector Std Dev (kt)

April

15° NE

Upper Air Climatology

Northern Hemisphere



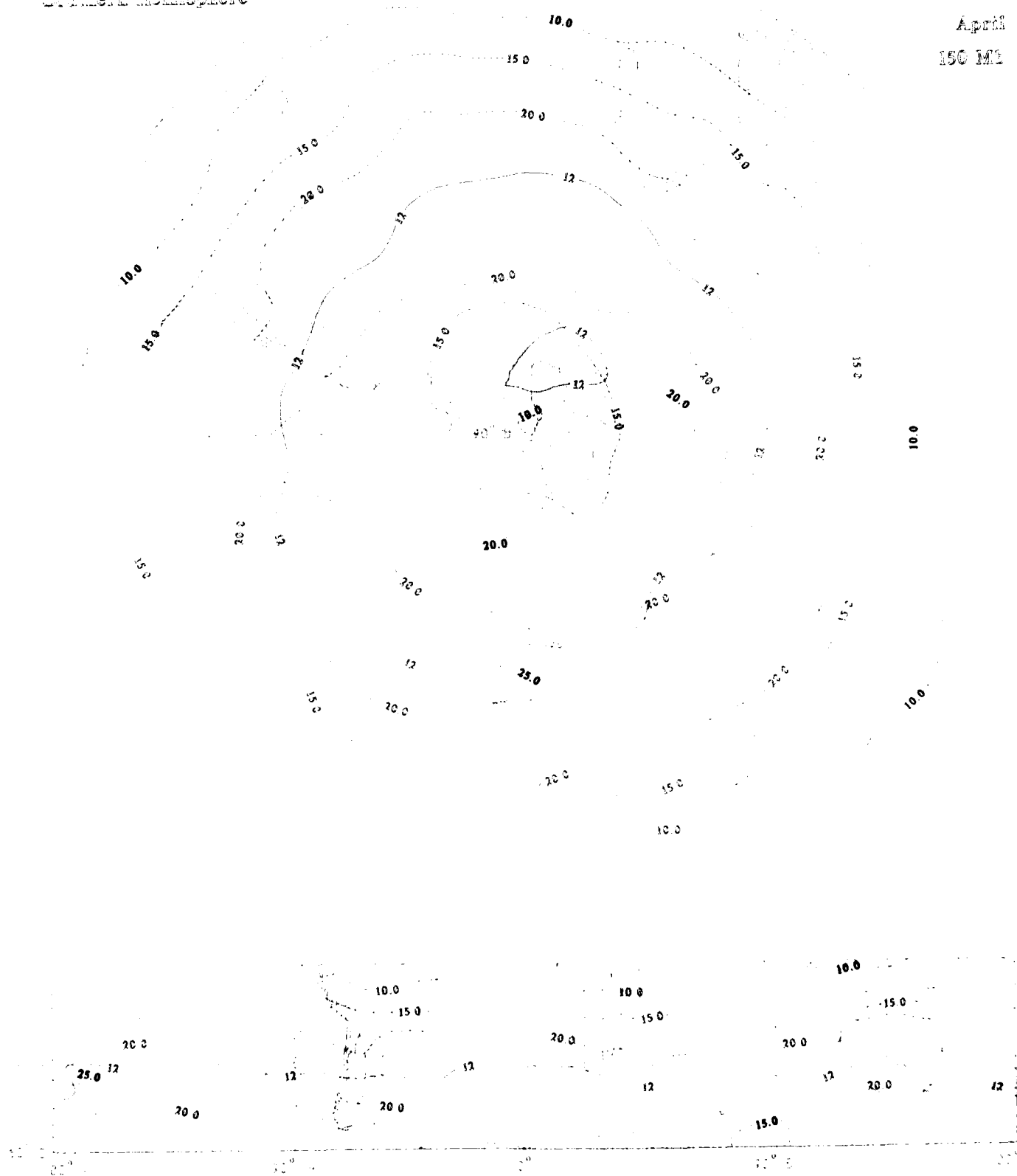
Upper Air Climatology
Southern Hemisphere

Height (dkm) Std Dev <Solid>

Vector Std Dev (kt)

April

150 MI



Height (km) Std Dev (Solid)

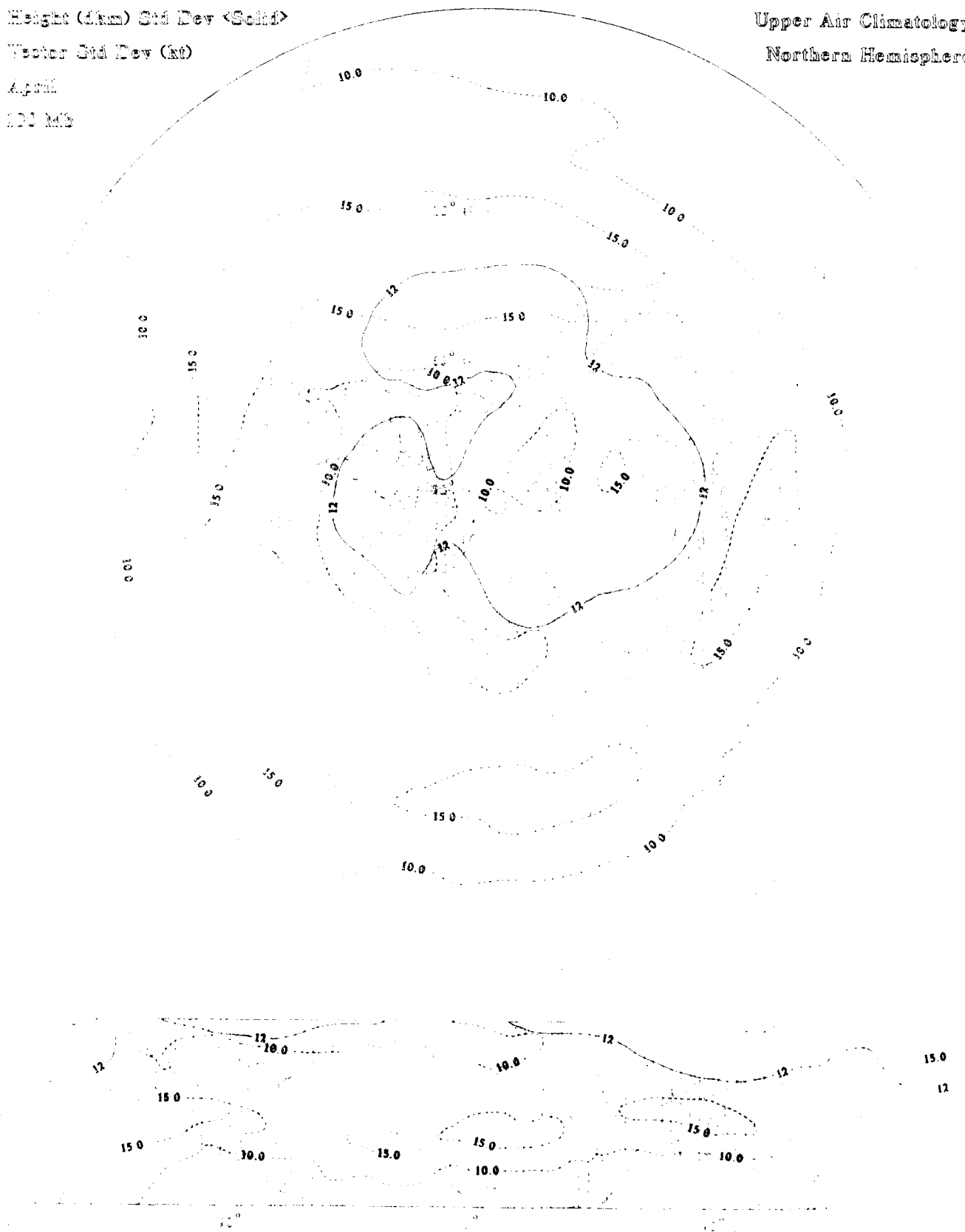
Vector Std Dev (kt)

April

100 MB

Upper Air Climatology

Northern Hemisphere



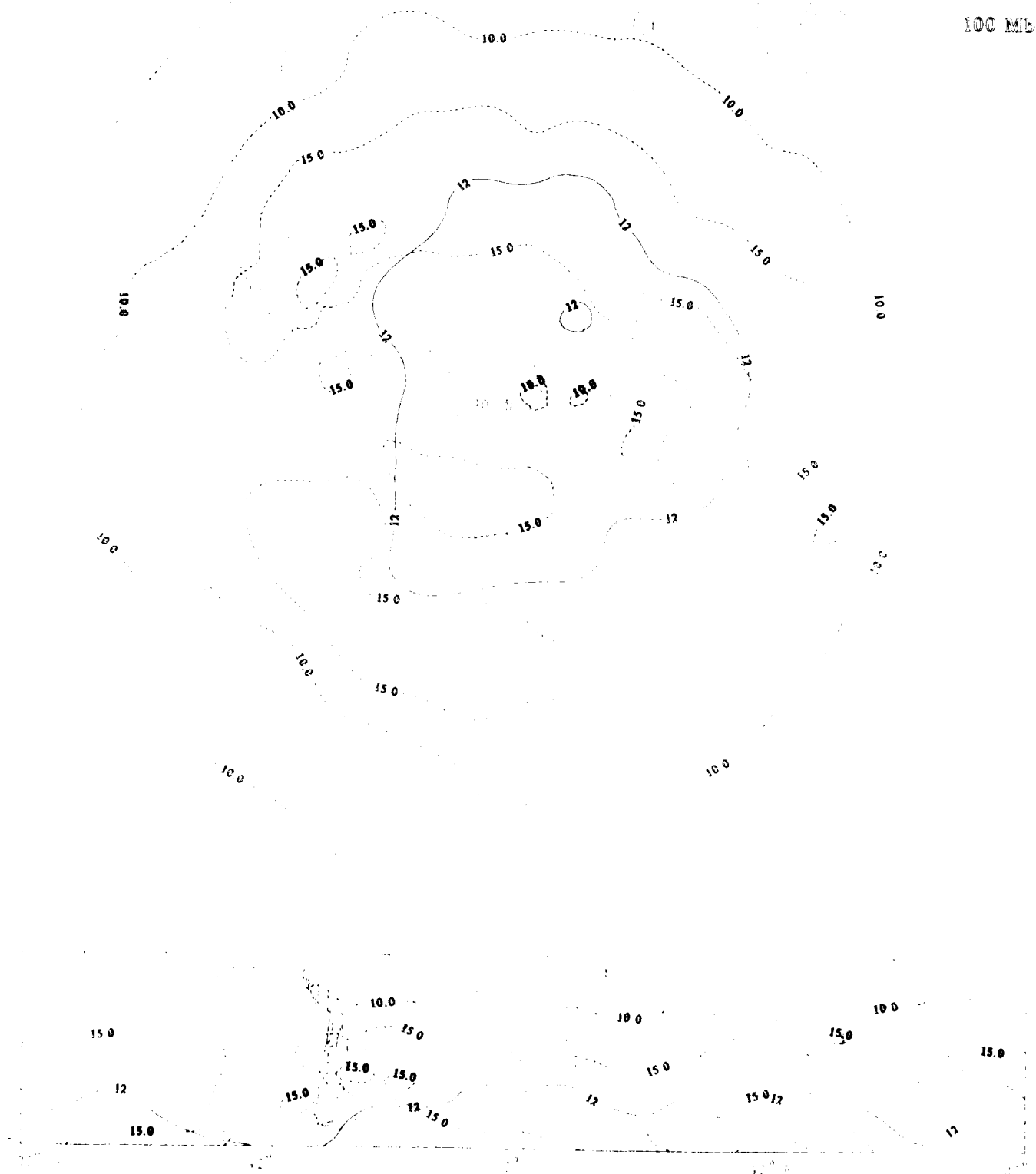
Upper Air Climatology
Southern Hemisphere

Height (dkm) Std Dev <Solid>

Vector Std Dev (kt)

April

100 MB



Height (dkm) Std Dev <Solid>

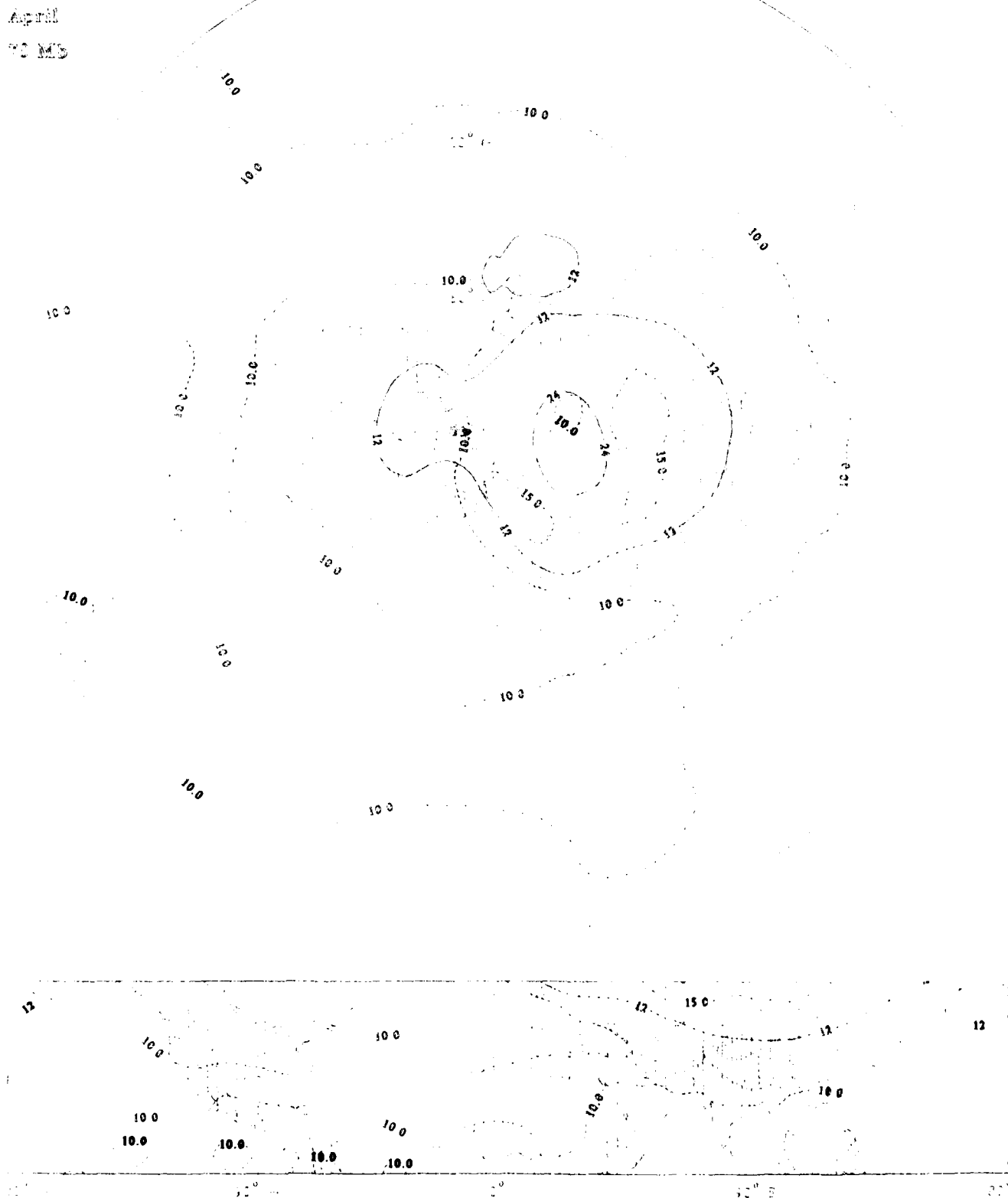
Vector Std Dev (kt)

April

70 MB

Upper Air Climatology

Northern Hemisphere



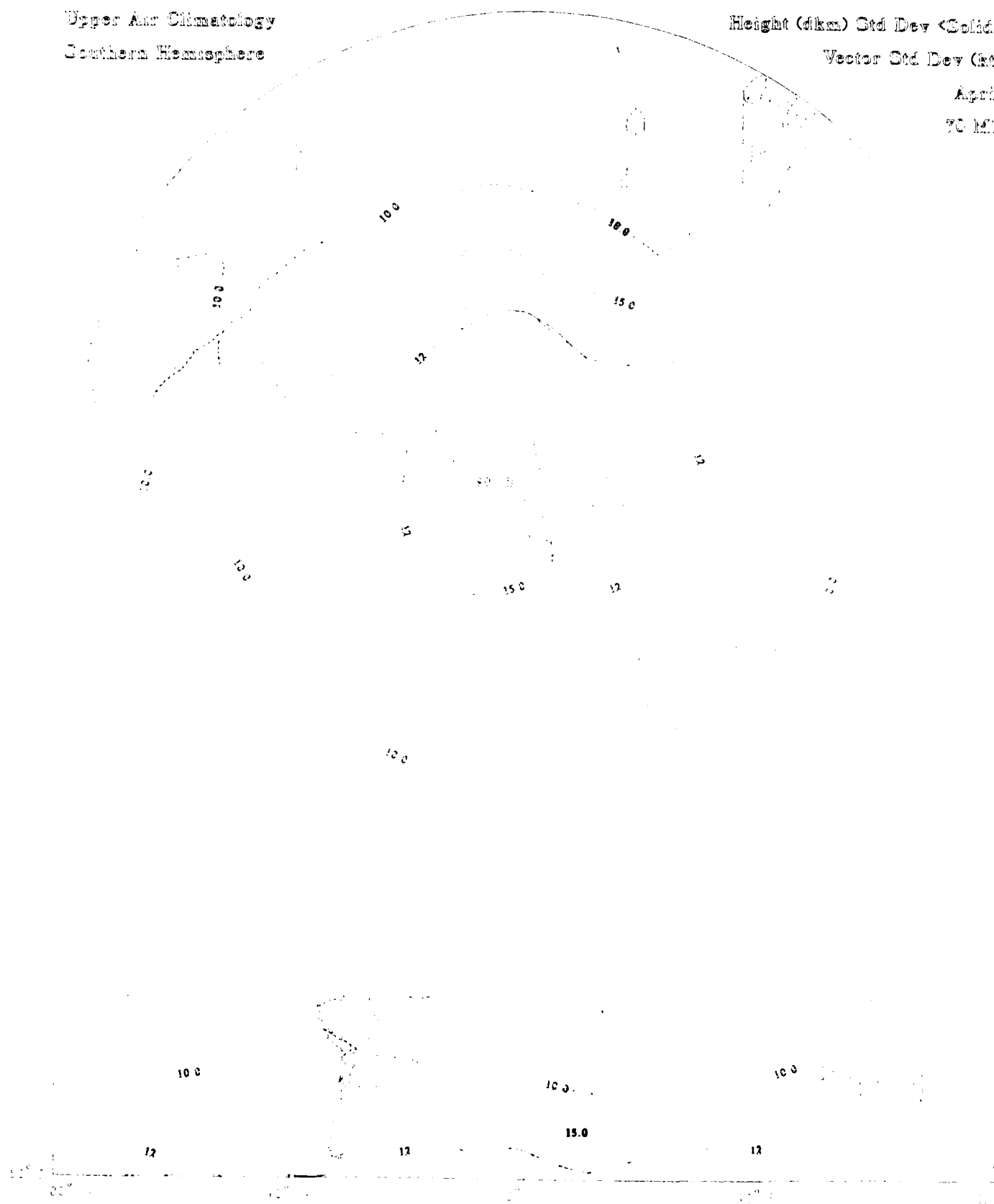
Upper Air Climatology
Southern Hemisphere

Height (dkm) Std Dev (Solid)

Vector Std Dev (kt)

April

70 ME



Height (dkm) Std Dev <Solid>

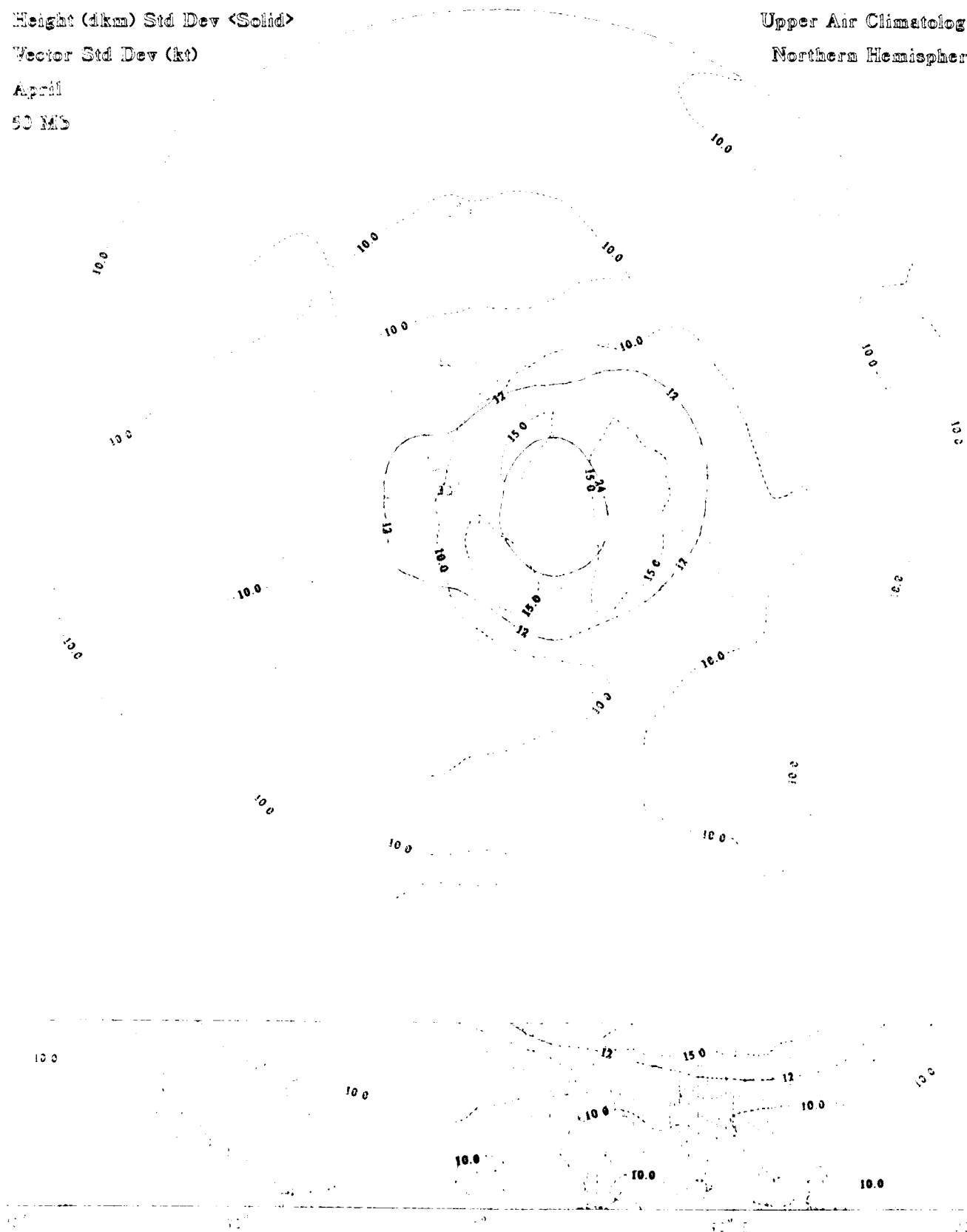
Vector Std Dev (kt)

April

50 MB

Upper Air Climatology

Northern Hemisphere



Upper Air Climatology
Southern Hemisphere

Height (dkm) Std Dev (Secs)

Vector Std Dev (kt)

April

50 MB



Height (dm) Std Dev (Solid)

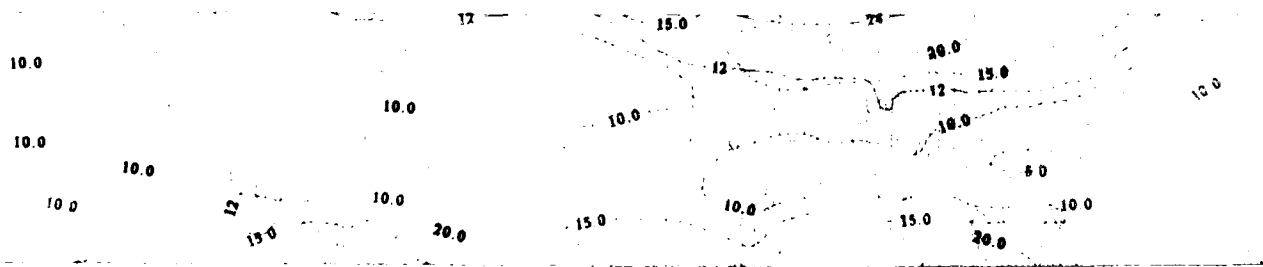
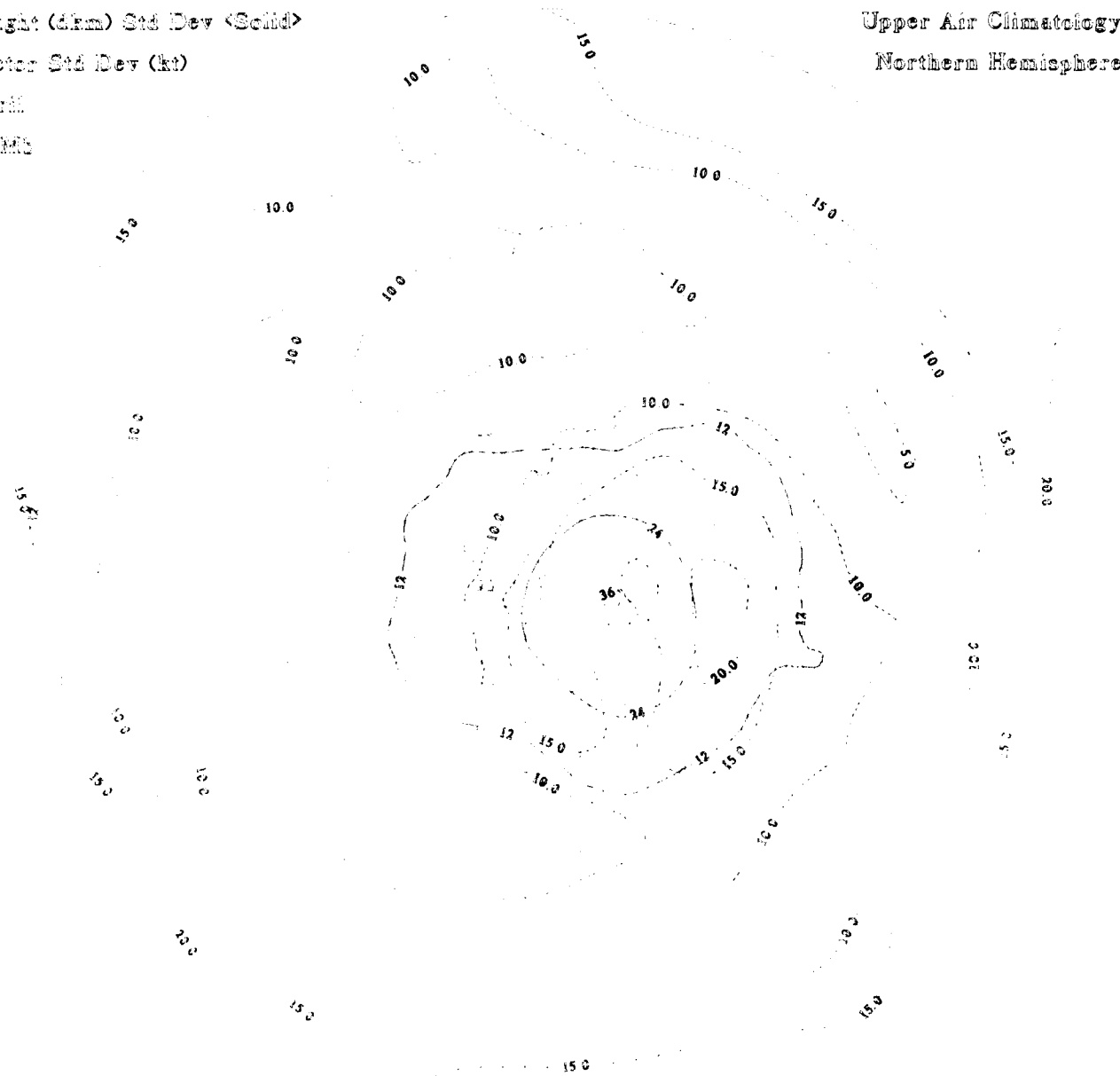
Vector Std Dev (kt)

April

10 MB

Upper Air Climatology

Northern Hemisphere



Upper Air Climatology
Southern Hemisphere

Height (gkm) Std Dev (Std)

Vector Std Dev (m)

April

20 125

